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FURTHER STUDIES ON VITAMIN E DEFICIENCY IN THE LAMB [1]

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F. Thorp, Jr. and R. L. Johnston [3]

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STIFF lamb disease is a significant factor affecting the sheep industry of this country. This disease causes the loss of a considerable number of lambs, which in some cases has been reported as high as 10–15 percent and even 50 percent in certain flocks.

Culik *et al.* (1951) reported that degenerative changes occurring in stiff lamb disease were similar to the nutritional muscular dystrophy produced in lambs fed a vitamin E deficient diet. Therefore, it was deemed important to study further the effects of vitamin E deficiency of the lamb. The present paper describes various chemical and histological changes produced by deficiency of vitamin E in the diet of the lamb.

Experimental Procedure

Fifteen 3- or 4-day-old lambs which had received colostrum from the dams, were placed in the experiment. All were males of the mutton and fine wool type. They were cared for and fed the same purified liquid diet used by Culik *et al.* (1951) which contained a molecular distilled lard. This lard, obtained from Distillation Products Inc., had less than five micrograms of total tocopherols per gram of lard and a high peroxide number.

Twelve of the animals were placed on the experimental diet, deficient in vitamin E, and three were kept as controls. The latter received the basal diet plus 100 mg. of d,l-α-tocopherol acetate orally every other day.

The progress of the vitamin E deficiency was measured every 10 days by the total tocopherol content of the blood plasma, and every

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20 days by the creatine-creatinine excretion in the urine. The creatine and creatinine determinations were performed according to the procedure of Peters (1942), and the determination of total tocopherols by the method described by Quaife and Harris (1944) and Quaife and Biehler (1945). Along with these analyses electrocardiographic studies were also carried out which will be reported in a separate communication.

Results and Discussion

Symptoms

The first indications of vitamin E deficiency were: lack of vigor, locomotor incoordination, leg weakness and a tendency to lie down most of the time. As the disease progressed lambs had to make repeated efforts before they could get up; later, they were unable to stand without help. These observations coincided with a poor appearance and progressive dystrophy of the skeletal muscles. In the final stages of vitamin E deficiency the lambs were unable to stand even when helped.

While the lambs were still able to walk, they showed wobbling joints, dragging feet, stiffness of the legs and a peculiar marching gait. When these lambs were forced to run, they ran with an excessively balancing movement from the front to the back and made very little progress. In several instances they fell on their knees and were unable to stand again.

Abnormalities were also noticed when the animals tried to turn around. The lambs turned with difficulty and with a pivot-like motion keeping their hind legs together.

Two of the lambs (Nos. 44 and 45) showed goose-stepping and two others repeatedly kicked the floor, and in both cases for a period of two to three days. This was unusual since such symptoms had never been reported before as being due to vitamin E deficiency. Locomotor incoordination (goose-stepping) is the characteristic symptom of pantothenic acid deficiency in the pig (Luecke *et al.*, 1949). Therefore, even though pantothenic acid was supplied in the diet, it was important to determine the level of pantothenic acid in the plasma of these animals for comparison with the plasma level of the deficient and control animals. Pantothenic acid determinations were run on the blood plasma of all the experimental and control animals according to the procedure outlined by Skeggs and wright (1944). The average values for pantothenic acid in the blood plasma of control lambs, vitamin E deficient lambs having muscular weakness, and vitamin E

deficient lambs showing goose-stepping were 0.40, 0.42 and 0.47 microgram per ml. respectively. The differences among the average values were not significant, which indicated that there is not any relationship between the pantothenic acid level of the blood plasma and any of the vitamin E deficiency symptoms.

These results confirm the observations of Culik *et al.* (1951) on the symptomatology of vitamin E deficiency in the lamb. In spite of the fact that the terminal histological lesions were identical in experimental vitamin E deficiency lambs and "stiff-lambs" raised under farm conditions, it must be recognized that the symptoms appearing in each case were different in some respects. Muscular weakness seemed to be the characteristic symptom of vitamin E deficiency, whereas muscular stiffness was the typical symptom of "stiff-lamb" disease. This may suggest the influence of other factors in addition to the absence of tocopherols in the case of "stiff-lamb" disease.

Treatment of Vitamin E Deficient Lambs

Treatment with an initial dose of 500 mg. of dl-α-tocopherol acetate followed by 100 mg. every other day by mouth was found very effective for the cure of two young lambs showing deficiency of vitamin E (Lamb Nos. 42 and 49). The therapy was more successful when the treatment was started soon after the appearance of the first symptoms. After a few days of treatment, the lambs showed great improvement in general vigor and strength of the legs. Treatment of third lamb (Lamb No. 50) was started when the animal wa in the final stages of the deficiency. The lamb was unable to stand up and was very emaciated. Recovery was surprisingly rapid; the lamb was able with some help to get up the day after α-tocopherol treatment was started, and two days later was able to stand up without assistance and walk dragging its feet. After 40 days of treatment, there was some improvement of muscular strength and of the ability to walk and run. However, the state of emaciation of the animal improved very little during the treatment.

Four of the vitamin E deficient lambs were used for an exploratory study of the effect of certain drugs on vitamin E deficiency. Prostigmine and cortisone were selected as the drugs most likely to influence the syndrome.

There were several reasons for using prostigmine. First, this drug has been shown to be effective in the treatment of several muscular disorders like myasthenia gravis of human beings, and second, vitamin E deficiency has been shown by Bloch (1942) and Hess and Biollier

(1948) to bring about a decrease of the cholinesterase enzyme. Therefore prostigmine, a drug known to prevent the destruction of acetylcholine by cholinesterase, should modify the effects of vitamin E deficiency. Two lambs were injected with 0.5 mg. of prostigmine subcutaneously daily for 15 days. Histological examination showed an attenuation of the effects of vitamin E deficiency.

Cortisone was used to treat the vitamin E deficient lambs because recent research work has demonstrated the value of this drug in the treatment of collagen disease (Engleman, 1950). Cortisone has been used successfully in several disorders of muscular functions like myotonia congenita (McEacher, 1951), menopausal muscular myopathy (Shy *et al.*, 1950 and McEacher, 1951) and post-operative stiffness of the hand (Baxter *et al.*, 1950). Since vitamin E deficiency in the lamb is a disease affecting the skeletal muscles, cortisone therapy was indicated. Two lambs receiving intramuscular injections of 50 mg. of cortisone daily for 15 days, showed some initial relief from the vitamin E deficiency, though later they looked the same as other vitamin E deficient lambs. Slices of muscular tissue showed that there had been some improvement as a consequence of the cortisone therapy.

The results indicated that these two drugs have a limited effect on the muscular dystrophy produced by vitamin E deficiency.

Urinary Creatine-Creatinine

Urinary creatine excretion increased in lambs deficient in vitamin E. Animals in initial stages of E deficiency excreted creatine at a rate of from 177 to 412 mg. per day (table 1), whereas common values for creatine excretion in control animals ranged from 18 to 86 mg. per day. However, in one instance, the creatine excretion of lamb No. 40 was 185 mg. per day. With the exception of lamb No. 50 the animals treated with α-tocopherol for 10 days had a level of urinary creatine excretion equal to that of controls.

The analyses of creatinine in the urine indicated that vitamin E does not significantly affect the urinary excretion of this compound. The amount of creatinine in the urine varied from animal to animal, but it remained about the same during the entire experimental period.

The creatinuria ratio was determined in order to condense in one expression the relative changes of creatine and creatinine produced by the absence of vitamin E in the diet. It was calculated by dividing the total creatinine (creatine plus preformed creatinine) by preformed creatinine. In control animals the creatinuria ratio was about 1.38

TABLE 1. URINARY CREATINE, CREATININE AND CREATINURIA RATIO IN VITAMIN E DEFICIENT LAMBS AND IN E DEFICIENT LAMBS SUBJECTED TO MULTIPLE THERAPY

Diet	Lamb No.	Days on Experiment: 0–10 C[a]	0–10 Cn[b]	0–10 C.R.[c]	20–30 C	20–30 Cn	20–30 C.R.	40–50 C	40–50 Cn	40–50 C.R.	60–70 C	60–70 Cn	60–70 C.R.
Basal	34	35	89	1.34	224	199	1.97	83	194	1.37			
	38	174	135	2.11	88	159	1.48	71	164	1.37	135[d]	147[d]	1.79[d]
	39	43	82	1.46	111	107	1.89	144	91	2.06			
	42	58	144	1.34	177	170	1.90	17[e]	163[e]	1.09[e]			
	43	16	122	1.11	216	168	2.11	89	183	1.42			
	44	60	100	1.52	48	72	1.57	132	119	1.96	66	66	2.92
	45	5	89	1.04	54	115	1.40	31	94	1.29	50[f]	157[f]	1.27[f]
	46	74	152	1.42	49	185	1.23	157[f]	174[f]	1.78[f]	76[f]	88[f]	1.75[f]
	47	121	116	1.90	6	136	1.04				412	135	3.63
	48	122	102	2.03	29	147	1.17						
	49				92	138	1.57	444	170	3.25	44[e]	108[e]	1.35[e]
	50	122	127	1.83	306[e]	167[e]	2.58[e]	42[e]	96[e]	1.38[e]	182[e]	83[e]	2.89[e]
	Av.[g]	75	114	1.55	99	145	1.58	142	145	1.82	239	100	3.28
Basal plus dl-α-tocopherol acetate	37	86	171	1.43	14	110	1.11	83	170	1.42			
	40	18	86	1.18	84	126	1.57	51	147	1.30	185	214	1.75
	41	56	84	1.57	45	136	1.29	52	215	1.21	29	207	1.12
	Av.[g]	53	114	1.39	48	124	1.32	62	177	1.31	107	210	1.44

[a] Creatine in mg. per day.
[b] Creatinine in mg. per day.
[c] Creatinuria ratio—the ratio of total creatinine (creatine plus creatine) to preformed creatinine.
[d] Prostigmine treatment.
[e] dl-α-tocopherol acetate treatment.
[f] Cortisone treatment.
[g] Average values calculated without taking into consideration d, e and f.

during the entire experiment, whereas during the same period the creatinuria ratio of deficient lambs increased from 1.55 to 3.28.

The creatinuria ratios calculated for the vitamin E depleted lambs of this experiment were somewhat similar to those found by Whiting, Willman and Loosli (1949) in sheep fed natural feeds. They considered a numerical creatinuria ratio larger than 1.3 as indicative of active muscular dystrophy. In this study the average creatinuria ratio of control animals was 1.38 and that of vitamin E deficient lambs was 2.05.

The α-tocopherol therapy of E deficient lambs reduced the creatinuria of most of the animals except in one advanced case (table 1). Apparently in this case the damage produced by the vitamin E deficiency was largely irreversible because neither the creatinuria ratio nor the general condition of the animal improved with the vitamin E treatment. This finding is in line with the result of Mason (1933) and Butturini (1949) who reported that the degeneration produced by vitamin E deficiency was reversible with vitamin E therapy up to a certain point, but it became irreversible when connective tissue was substituted for the functioning parenchyma.

The effects of cortisone and prostigmine therapy on the creatinuria of vitamin E deficient lambs are inconclusive due to the small number of treated animals.

Blood Plasma Tocopherol

Lambs having a high initial content of plasma tocopherols did not require a longer period to become vitamin E deficient than those having a lower initial content.

The tocopherol levels of lambs fed the basal diet decreased gradually during the experimental period from 0.110 to 0.079 mg. per 100 ml. of plasma (table 2). Control animals underwent the reverse process, the tocopherol levels gradually increasing from 0.099 to 0.215 mg. per 100 ml. of plasma in the same period of time.

However, it should be pointed out that the change in tocopherol content of blood plasma of deficient lambs was not always one of a progressive decrease. In some instances, lambs having low values for 20–30 days showed a sudden and unexplained increase of total tocopherol in the blood plasma. This phenomenon did not last more than 10 days, after which the tocopherol content usually fell to the original low levels.

Low tocopherol values did not always coincide with overt signs of vitamin E deficiency. But lambs showing overt signs of vitamin E

TABLE 2. TOTAL TOCOPHEROL CONTENT OF BLOOD PLASMA IN LAMBS FED A VITAMIN E DEFICIENT DIET AND IN VITAMIN E DEFICIENT LAMBS SUBJECTED TO SEVERAL THERAPIES

(All values expressed in mg. per 100 ml. of blood plasma)

Diet	Lamb No.	Days on Experiment					
		0–10	20–30	30–40	40–50	50–60	60–70
Basal	34		0.228	0.050	0.187[a]	0.116	
	38	0.162	0.084	0.103	0.069	0.131[a]	0.069[d]
	39	0.040	0.097	0.091	0.097	()[b]	
	42	0.127	0.156	0.078	0.084[e]	0.384[e]	
	43	0.116	0.097	0.091	0.069	0.200[a]	0.153[a]
	44	0.097	0.134	0.128	0.250[a]	0.069	0.063
	45		0.050	0.069	0.200[a]		0.081[f]
	46	0.125	0.250[a]	0.097	0.119[f]	0.069[f]	0.063[f]
	47	0.097	0.103	0.097	0.806[a]	0.100	0.000[a]
	48	0.084	0.050	0.069	()[b]		
	49	0.103	0.150	0.131	0.084	0.313[e]	
	50	0.147	0.069	0.128[e]	0.069[e]	0.175[e]	
	Av.[c]	0.110	0.111	0.091	0.079	0.095	0.063
Basal plus dl-α-tocopherol acetate	37	0.159	0.228	0.162	0.299	0.406	0.428
	40	0.059	0.112	0.091	0.187	0.234	0.175
	41	0.078	0.172	0.332	0.159	0.366	0.294
	Av.	0.099	0.171	0.195	0.215	0.335	0.299

[a] Unexpected values.
[b] Sudden death of the lamb.
[c] Average values calculated without taking into consideration a, d, e and f.
[d] Prostigmine treatment.
[e] dl-α-tocopherol acetate treatment.
[f] Cortisone treatment.

deficiency invariably had low values of tocopherols ranging from 0.050 to 0.081 mg. per 100 ml. of blood plasma.

Macropathology of Vitamin E Deficiency

The macropathological findings were similar to those reported by Culik *et al.* (1951). However, there were several new findings worthy of mention. In two instances it was observed that lambs had very edematous muscles, especially in some muscles of the thigh. It was also found in these same animals and in another showing goose-stepping, that the sciatic nerve was surrounded by a thick fatty coat, yellow in color.

One of the most interesting findings of this work was the confirmation of the regular appearance of heart injuries in vitamin E deficient lambs. It is possible that natural rations causing "stiff-lamb" disease may contain other factors which could modify the effect of vitamin E deficiency. This explanation seems feasible since certain manifestations of vitamin E deficiency have been shown to be affected by the interaction of other factors. In the chicken, Dam (1944) demonstrated that the symptoms of vitamin E deficiency depended on the iodine number of the fat contained in the diet.

The heart lesions, found in the present experiment, were indiscriminately located in both sides of the heart, which does not corroborate the results of Willman *et al.* (1945) and Culik *et al.* (1951). Nevertheless according to the work of Moe and Visscher (1940) it was possible that the difference in the location of heart lesions could have been due to the presence or absence of pneumonia. Moe and Visscher found that Thebesian veins were relatively insignificant factors in the nutrition of the left heart. These veins emptied into the heart chamber and therefore were subjected to the changes of heart loads. Thus, the nutrition of the right ventricle was dependent on factors affecting the right intraventricular pressure like mitral stenosis, pulmonary embolism and pulmonary fibrosis. However, the simultaneous study of the total relative size of injured areas in both sides of the heart and in lungs did not disclose any relationship of pneumonia to the localization of injuries in the right ventricle of the heart.

Histological Findings

The changes produced by vitamin E deficiency in skeletal muscles of lambs can be summarized as a process involving hyaline degenera-

tion of the sarcoplasma and a coagulation necrosis in the presence of cellular infiltration.

The muscle fibers first became swollen, shrunken and fragmented while the cross and longitudinal striations disappeared. These fibers stained deeper with the hematoxylin-eosin (figures 1 and 2).

At the same time that the degenerative process was taking place the reverse process of regeneration was also noticed. This was characterized by an increased proliferation of muscular fiber nuclei, which induced formation of new fibers. The new fibers stained fainter with the hematoxylin-eosin and showed the multiple nuclei arranged in rows at the center of the fiber (figure 5). The sarcoplasma of the muscle fibers became granular then vacuolized, at the same time that the nuclei ordinarily became pyknotic (figure 3). The final stage of the degenerative process was marked by death of muscle fibers. The necrotic process was accompanied by infiltration of a few polymorphonuclear leukocytes, many macrophages and giant cells. The latter had the role of cleaning the detritus from the necrotic area (figure 4). As the muscle fibers disappeared there was an active proliferation of fibroblasts which tended to fill the empty space left by the muscle fibers. However, at the time of muscle regeneration the muscle nuclei and fibers overshadowed the fibroblastic proliferation.

The heart muscle essentially underwent the same changes as the skeletal muscles. But it can be added that the degenerative process started from the endocardium and progressed towards the epicardium. Other relevant characteristics of the histological picture of a vitamin E deficient heart were the absence of giant cells and the integrity of the Purkinje fibers, in spite of the fact that all the surrounding cells were severely affected (figure 6).

The recovery of deficient animals treated with α-tocopherol was apparent through the increased proliferation of muscular fiber nuclei, as well as the number of macrophages and giant cells. The origin of the regenerating fibers was thought to be in the sarcolemma or in the actively proliferating nuclei. It seemed that the most active part of the regenerating fibers was the rounded end of the new fibers. It was observed that when the time of therapy was longer there were lesser histological abnormalities. The therapy aforementioned, therefore, seemed to have been satisfactory. Nevertheless, it cannot be said that the tissues of lambs treated with vitamin E for 40 days were perfectly normal, since there was an increased number of cell nuclei. Probably a more prolonged treatment would have lowered the number of cell nuclei to a normal value.

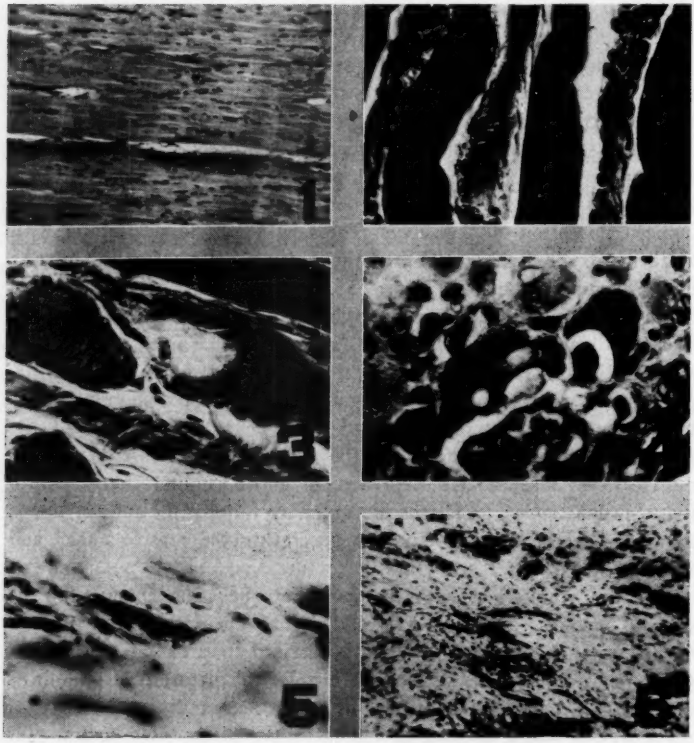

Figure 1. Longitudinal section of normal skeletal muscle from a positive control lamb. H & E stain x 57.

Figure 2. Initial stage of muscle degeneration showing extensive cellular infiltration and loss of striation of some fibers. H & E stain x 383.

Figure 3. A more advanced stage of degeneration showing vacuolization of affected fibers. H & E stain x 383.

Figure 4. Histiocytic and giant cell reaction in an area of vacuolar degeneration. H & E stain x 383.

Figure 5. Regenerating muscle with numerous nuclei arranged in a row in the center of the fiber. H & E stain x 383.

Figure 6. Degenerated and necrotic cardiac muscle in which the Purkinje fibers appear to be normal. H & E stain x 57.

Summary

An experiment was set up to study further the effects of vitamin E deficiency in the lamb. The results of this work confirmed findings of previous investigations. The main manifestation of vitamin E defi-

ciency was muscular weakness which developed parallel to the muscular dystrophy. Evidence of muscular defection were wobbling joints, dragging feet, mild stiffness of the legs and a peculiar marching gait.

Treatment with dl-α-tocopherol acetate was again shown effective to cure and prevent vitamin E deficiency in the lamb. However, dl-α-tocopherol acetate was ineffective in completely restoring the health of lambs in an advanced stage of vitamin E deficiency.

Treatment with cortisone and prostigmine attenuated, to a certain extent, the symptoms of vitamin E deficiency. However, it seemed that these drugs did not have a predominant influence on the development of muscular dystrophy due to vitamin E deficiency.

Lambs showing symptoms of vitamin E deficiency had high creatine values in the urine, ranging from 177 to 412 mg. per day and low values of total tocopherol in the blood plasma which ranged from 0.050 to 0.081 mg. per 100 ml. of blood plasma.

Histological changes of skeletal muscles due to vitamin E deficiency can be described as a process involving hyaline degeneration of the sarcoplasma and a coagulation necrosis in the presence of cellular infiltration. Except for the absence of giant cells in the degenerated cardiac muscles, the heart lesions were similar to those of skeletal muscles. They progressed from the endocardium to the epicardium without damaging the Purkinje fibers.

The comparison of symptoms and histological findings in vitamin E deficient and "stiff lambs" suggests the possible influence of other factors in addition to the absence of tocopherols in the case of "stiff-lamb" disease.

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RATION FACTORS AFFECTING THE UTILIZATION OF UREA NITROGEN BY LAMBS [1]

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SEVERAL years ago workers at Wisconsin (Mills *et al.* 1942, 1944; Wegner *et al.*, 1941a, 1941b) observed that the utilization of urea nitrogen by rumen organisms was markedly affected by the type of carbohydrate and nature and level of protein in the rumen ingesta. Their studies were conducted with heifers having a rumen fistula, and with growing dairy calves. Confirmation of their results by the *in vitro* experiments of Pearson and Smith (1943) has strengthened the opinion that for maximum use of urea as a source of nitrogen in ruminant rations there should be supplied a certain percentage of readily fermentable carbohydrate of low solubility, such as starch, and a low level of protein derived from natural feeds. The exact proportion of these constituents which will promote the greatest synthesis of protein from urea nitrogen is not known. The current studies of Burroughs and associates (1951a, 1951b, 1951c) bear upon this point and also indicate that certain minerals are of special value.

Recent experiments have failed to reveal major differences between the common cereal grains as sources of carbohydrate in urea rations fed to steers (Bell, Gallup and Whitehair, 1951). The possibility that urea will more effectively supplement some protein concentrates than others is suggested in the work of Mills *et al.* (1942) and Pearson and Smith (1943). Both groups of investigators observed poor utilization of urea nitrogen in the presence of a readily hydrolyzable protein such as casein. McNaught and Smith (1947) and Burroughs *et al.* (1951b) have discussed factors involved in the utilization of urea nitrogen in the presence of proteins.

The present experiments were undertaken to determine by nitrogen balance procedures (1) the value of urea in rations containing different proportions of roughage and concentrate, (2) the efficiency of utilization of increasing amounts of urea added to a high-carbohydrate ration and (3) the supplemental value of urea in rations containing different

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protein concentrates. The practical significance of the results relates to the type and composition of rations most suitable for urea supplementation.

Experimental

Texas feeder lambs of mixed breeding having initial weights of about 60 pounds were used in these experiments. The equipment used and the methods of procedure have been described in previous reports of nitrogen balance studies (Briggs and Gallup, 1949; Gallup, Briggs and Hatfield, 1950).

The first experiment involved trials in which three basal rations containing 84, 49 and 28 percent roughage as cottonseed hulls, and a fourth ration containing 49 percent roughage as prairie hay, were fed alone and supplemented with urea. The protein content of the basal rations was adjusted to about 7 percent by changes in the proportion of cottonseed meal, corn and starch in the concentrate feed. Equal amounts of urea were added to raise the protein equivalent of each ration to about 10 percent. A mineral mixture of salt, calcium carbonate and bonemeal was used to supply adequate amounts of calcium and phosphorus. The trials with the prairie hay rations were conducted after it was observed that the 49-percent hull ration barely supported nitrogen equilibrium. Although prairie hay has about the same crude protein content as cottonseed hulls, it is higher in digestible protein and lower in crude fiber. The composition of these rations is shown in table 1.

In the second experiment, urea was added in increasing amounts to a low-protein, high-carbohydrate ration to determine the minimum amount that would permit near maximum nitrogen retention. The basal ration was composed of cottonseed hulls 37.4 percent, cottonseed meal 6.6, ground corn 28.0, corn starch 14.3, brown sugar 10.3, corn oil 1.0, and minerals 2.4. It supplied 7.1 percent protein. The mineral mixture contained salt 41.8 percent, bonemeal 47.7, sodium sulfate 8.4, and trace minerals (iron, copper, cobalt, iodine and manganese) 2.1. Additions of urea were made in amounts to provide rations having the equivalent of 8.5, 10.2, and 12.5 percent protein. In two sets of trials in this experiment, cottonseed meal replaced an equivalent weight of starch, sugar and oil to provide rations containing 8.5 and 12.3 percent protein derived entirely from plant sources, for comparison with two of the urea rations of equivalent protein content.

In the third experiment three basal rations, one made up with

cottonseed meal, another with soybean oil meal, and a third with corn gluten meal, were used for supplementation with urea. The average composition of the basal rations was cottonseed hulls 37.0 percent, protein concentrate 7.0, ground corn 28.6, corn starch 14.3, brown sugar 9.7, corn oil 1, and minerals 2.4. They were made equal in protein content by minor adjustment in the proportion of meal and starch, 43 percent of the total protein in each ration being supplied

TABLE 1. LOW-PROTEIN BASAL RATIONS FED TO LAMBS IN EXPERIMENT I

Ration Designation	High Hulls	Medium Hulls	Low Hulls	Medium Hay
	%	%	%	%
Constituents				
Cottonseed hulls	84	49	28	0
Prairie hay	0	0	0	49
Ground corn	0	42	49	42
Corn starch	7	7	21	7
Cottonseed meal	7	0	0	0
Minerals	2	2	2	2
Composition, dry matter basis				
Organic matter	94.87	95.33	96.02	93.88
Protein (N×6.25)	7.20	6.80	6.42	6.47
Ether extract	1.02	1.88	2.19	2.52
Crude fiber	33.85	21.29	11.74	17.86
N-free extract	52.80	65.36	75.67	67.03

by the meal. The mineral mixture was the same as that used in the second experiment. When supplemented with equal amounts of urea, the protein content of each ration was raised from 7.8 percent to the equivalent of 10.6 percent. Sixty percent of the total nitrogen in these urea-supplemented rations was supplied by the high-protein meal and urea.

In all experiments vitamins A and D were supplied in the rations by the daily addition of 1 ml. of high potency fish-liver oil. A constant amount of ration was fed daily in all trials and any lamb that refused feed was removed from the trial. By using a high proportion of natural feeds in the basal rations, feed refusals were infrequent. The urea used in the supplemented rations in all three experiments was added as duPont "Two-Sixty-Two," a commercial preparation of urea containing 42 percent nitrogen. Results were treated statistically by the method of analysis of variance (Snedecor, 1946).

Results

The results of the first experiment with high, medium and low-roughage rations are presented in table 2.

Urea supplementation of each of the rations shown in table 2 resulted in a small but consistent increase in fecal nitrogen excretion and an appreciable increase in the urinary nitrogen output. The increase in fecal nitrogen, similar to that induced by increased protein intake, is believed to indicate ruminal synthesis of protein. A similar increase occurs when urea is added to a nitrogen-free ration and is accompanied by an increase in digestibility of crude fiber in the ration (Harris and Mitchell, 1941). This increase in fecal nitrogen has been observed in previous experiments with lambs fed urea-supplemented rations, and in those experiments analysis of the feces indicated that the nitrogen was in some other form than urea or ammonia (Gallup and Dinning).

The high-hull basal ration was low in digestible nitrogen and apparently low in available energy. When this ration was fed, nitrogen output in the urine exceeded the amount of nitrogen absorbed. Supplementation of the ration with urea, although providing an increased amount of digestible nitrogen, failed to change significantly the character of the negative nitrogen balance. Only small amounts of the supplemental nitrogen were utilized. The medium-hull basal ration, also low in digestible nitrogen but containing more energy supplied by corn, permitted a positive daily nitrogen balance of 0.26 gm. Urinary nitrogen excretion was less with this ration than with the high-hull ration. Supplementation with urea effected a small increase in the nitrogen balance, although the total amount of nitrogen retained was only 5 percent of the intake and 12 percent of the amount absorbed. Apparently conditions relating to the composition of the high- and medium-hull rations were unfavorable for the efficient utilization of urea nitrogen. Differences in nitrogen retention between these basal and urea-supplemented rations were not statistically significant. The low-hull basal ration, which contained increased amounts of corn and starch and supplied considerably more digestible nitrogen than the preceding basal ration, permitted a positive nitrogen balance of 1.22 gm. Supplementation with urea increased significantly the amount of nitrogen retained to 2.30 gm. Despite the relatively large amounts of nitrogen absorbed, nitrogen excretion in the urine was no greater with these rations than with the corresponding medium-hull rations; as a consequence, 21.8 percent of the total nitrogen and 36.7 percent of the absorbed nitrogen in the urea-supplemented ration was retained.

Although only four trials were conducted with the medium-hay ration,

TABLE 2. EXPERIMENT 1. RESULTS OF DIGESTION AND NITROGEN BALANCE[1] TRIALS WITH HIGH-, MEDIUM- AND LOW-ROUGHAGE RATIONS

Ration type	High Hulls		Medium Hulls		Low Hulls		Medium Hay	
Rations compared[2]	Basal	Basal Plus Urea	Basal	Basal Plus Urea	Basal	Basal Plus Urea	Basal	Basal Plus Urea
Protein content (N×6.25), percent[3]	7.20	10.28	6.81	9.94	6.44	9.88	6.47	9.96
Number of lambs	3	4	4	4	8	4	2	2
Weight of lambs, lb.	65	64	67	65	67	66	71	70
Daily dry matter intake, gm.	644	655	644	651	658	667	652	661
Nitrogen intake, gm.	7.43	10.78	7.02	10.40	6.78	10.55	6.74	10.51
Nitrogen in feces, gm.	5.91	6.38	5.23	5.68	4.06	4.26	3.66	4.00
Nitrogen in urine, gm.	2.06	4.72	1.53	4.17	1.50	3.99	1.60	3.88
Nitrogen absorbed,[4] gm.	1.52	4.41	1.79	4.72	2.72	6.39	3.08	6.51
Nitrogen retained, gm.	−0.54	−0.32	0.26	0.55	1.22	2.30	1.48	2.63
Nitrogen retained as percent of intake	....	....	3.7	5.3	18.1	21.8	22.0	25.0
Nitrogen retained as percent of absorbed	....	....	14.5	11.7	45.0	36.7	48.0	40.4
Biological value[5]	....	....	....	61.4	....	69.9	....	72.1
Digestibility coefficients								
Protein (N×6.25)	20.5	41.0	25.6	45.4	40.1	59.6	45.6	61.9
Organic matter	43.4	51.5	55.8	63.2	67.7	73.5	57.1	64.1
Crude fiber	40.7	44.4	34.8	36.0	13.7	25.4	43.9	53.5

[1] Nitrogen balance data are on a daily basis.
[2] Urea supplied about 36 percent of the total nitrogen in the supplemented rations.
[3] Protein content of rations is on a dry matter basis.
[4] Apparent digested nitrogen.
[5] Calculated on the basis of metabolic nitrogen=0.55 gm. per 100 gm. dry matter intake, and endogenous nitrogen=0.033 gm. per kg. body weight (Harris and Mitchell, 1941). Values were calculated for only those rations which contained about 10 percent of protein and permitted a positive nitrogen balance.

average nitrogen retention values of 1.48 gm. for the basal, and 2.63 gm. for the urea-supplemented ration, afford evidence that it was superior to the medium-hull ration and equal to the low-hull ration in promoting efficient use of urea. In fact, the results obtained with this ration and the different hull rations make it appear that the usefulness of urea nitrogen is influenced by type as well as the proportion of roughage fed. In this series of balance trials, urea proved to be of greatest value when used to supplement the low-hull and medium-hay rations, the increase in nitrogen retention so effected amounting to about 30 percent of the urea nitrogen supplied.

TABLE 3. EXPERIMENT 2. RESULTS OF DIGESTION AND NITROGEN BALANCE [1] TRIALS WITH RATIONS INCREASED IN NITROGEN BY UREA AND COTTONSEED MEAL

Rations compared	Basal	Basal Plus Urea	Basal Plus Urea	Basal Plus Urea	Basal Plus C.S.M.	Basal Plus C.S.M.
Protein content (N×6.25), percent [2]	7.07	8.45	10.13	12.32	8.39	12.20
Number of lambs	4	4	4	4	4	4
Weight of lambs, lb.	61	61	65	64	68	70
Daily dry matter intake, gm.	624	627	631	637	631	630
Nitrogen intake, gm.						
From basal	7.07	7.07	7.07	7.07	7.07	7.07
From supplement	....	1.41	3.15	5.47	1.41	5.22
Total	7.07	8.48	10.22	12.54	8.48	12.29
Nitrogen in feces, gm.	5.03	4.88	5.04	5.03	4.82	5.20
Nitrogen in urine, gm.	1.47	1.80	2.56	5.22	1.61	4.17
Nitrogen retained, gm.	0.57	1.80	2.62	2.29	2.05	2.92
Nitrogen retained as percent of intake	8.1	21.3	25.6	18.3	24.2	23.8
Digestibility, percent						
Protein (N×6.25)	28.8	43.2	50.7	59.9	43.1	57.6
Organic matter	58.0	67.3	71.5	72.8	66.0	72.0
Crude fiber	24.9	42.5	49.4	51.4	39.9	54.5

[1] Nitrogen balance data are on a daily basis.
[2] Dry matter basis.

A further value of urea is clearly shown in a comparison of the digestibility coefficients of table 2. It increased significantly the digestibility of organic matter (dry matter minus ash) in all hull rations by 6–8 percentage units and nearly doubled the amount of crude fiber digested in the low-hull ration. It had a similar effect in the hay ration. The repressed digestibility of crude fiber associated with increasing amounts of readily available carbohydrate in the hull rations was partially overcome by the urea supplements.

The results of the second experiment in which increasing amounts of urea were added to a low-protein basal ration are shown in the nitrogen balance data of table 3. The basal ration which contained

7.1 percent protein derived largely from cottonseed meal and corn permitted a nitrogen retention of 0.57 gm. Increasing the nitrogen content of the ration to the equivalent of 8.5 and 10.2 percent protein by urea resulted in nitrogen retentions of 1.80 gm. and 2.62 gm., respectively. Further supplementation with urea to increase the protein equivalent of the basal ration to 12.5 percent, however, brought about no further increase in nitrogen retention. The increases in nitrogen retention at the 8, 10 and 12 percent protein levels, over that attained with the basal ration, were equivalent to 87, 65 and 31 percent of the added urea nitrogen.

When cottonseed meal was used to increase the protein of the basal ration to 8.5 percent, nitrogen retention was not significantly different from that attained with the urea ration of similar nitrogen content; at the 12 percent level, however, cottonseed meal induced a higher average retention of nitrogen than occurred with urea. Somewhat similar results have been reported by Johnson *et al.* (1942) with lambs fed soybean meal and urea rations at slightly higher levels of nitrogen intake.

The effect of urea on the digestibility of organic matter and crude fiber in the ration was similar to that observed in the first experiment. As might be expected, apparent digestibility of protein was positively correlated with the protein content of the ration. The digestibility of organic matter was increased from a value of 58 percent in the basal ration to 71.5 percent or more in the 10- and 12-percent protein rations; crude fiber digestibility, which was 24.9 percent in the basal ration, was increased two-fold. Differences in digestibility values between the urea and cottonseed meal rations of equivalent protein content were not significant.

The results of balance trials of the third experiment in which urea supplemented the nitrogen of different protein concentrates are shown in table 4. The three basal rations furnished equal amounts of nitrogen at a level slightly higher than that of the basal ration used in the preceding experiment. With cottonseed meal, soybean oil meal and corn gluten meal as the protein concentrates in the basal rations, nitrogen retentions were 1.19, 0.86 and 1.09 gm., respectively. When each ration was supplemented with an equal amount of urea to increase nitrogen to the equivalent of 10.6 percent protein, nitrogen retentions in the same order were 2.32, 2.26 and 2.43 gm., and the biological value of the nitrogen in the supplemented rations was 78.4, 75.0 and 78.1. Differences between the supplemented rations in these measures of nitrogn utilization were not statistically significant. Thus, it seems

evident that urea was as well utilized in the presence of one protein concentrate as another.

As in experiments 1 and 2 urea increased significantly the digestibility of organic matter and crude fiber in the basal rations. A similar effect might logically be expected in supplementing low-protein rations with urea under practical methods of feeding. Although the demonstration of such a specific effect might not be possible, weight gain per unit of feed intake would be a practical measure of the over-all value of the supplemental nitrogen.

TABLE 4. EXPERIMENT 3. RESULTS OF DIGESTION AND NITROGEN BALANCE [1] TRIALS WITH UREA AS A SUPPLEMENT TO RATIONS CONTAINING DIFFERENT PROTEIN CONCENTRATES

Ration identification	Cotton Seed Meal (Basal)	C.S.M. Basal Plus Urea	Soybean Oil Meal (Basal)	S.B.M. Basal Plus Urea	Corn Gluten Meal (Basal)	C.G.M. Basal Plus Urea
Protein (N×6.25), percent [2]	7.80	10.61	7.78	10.59	7.80	10.61
Number of lambs	8	7	6	6	7	7
Weight of lambs, lbs.	67	68	69	69	67	69
Daily dry matter intake, gm.	627	634	628	635	626	633
Nitrogen intake, gm.	7.73	10.67	7.73	10.68	7.72	10.62
Nitrogen in feces, gm.	5.01	5.45	5.07	5.13	4.87	5.21
Nitrogen in urine, gm.	1.53	2.90	1.80	3.29	1.76	2.98
Nitrogen retained, gm.	1.19	2.32	0.86	2.26	1.09	2.43
Biological value,[3] percent	....	78.4	....	75.0	....	78.1
Digestibility, percent						
Protein (N×6.25)	35.0	48.8	34.4	51.9	36.9	50.7
Organic matter	61.4	68.9	65.8	71.9	61.2	71.4
Crude fiber	28.9	42.6	32.1	44.0	23.8	44.5

[1] Nitrogen balance data are on a daily basis.
[2] Dry matter basis.
[3] See footnote 5 of table 2.

Summary

The value of supplemental nitrogen added as urea to different basal rations containing about 7 percent protein was studied in a series of digestibility and nitrogen balance trials with lambs.

The first experiment was conducted with three basal rations containing 84, 49 and 28 percent roughage supplied as cottonseed hulls, and a fourth ration containing 49 percent as prairie hay. The nitrogen content of the rations was made equivalent to 10 percent protein by supplementation with equal amounts of urea. Differences in nitrogen retention between the basal and urea-supplemented rations demonstrated that with decreasing hulls in the rations, increasing amounts of urea nitrogen were retained. The 49-percent hay ration was equivalent to the 28-percent hull ration in supporting increased nitrogen retention.

In the second experiment the protein equivalent of a basal ration containing 37 percent cottonseed hulls was increased to 8.5, 10.1 and 12.3 percent by addition of urea, and to 8.4 and 12.2 percent by substitution of cottonseed meal for carbohydrate feeds. Maximum nitrogen retention with the urea-supplemented rations was reached at the 10 percent protein level. A slightly higher retention was attained with the cottonseed meal ration at the 12 percent level.

In the third experiment comparisons were made with three basal rations containing cottonseed meal, soybean oil meal, and corn gluten meal. Without supplementation, these rations permitted similar nitrogen retentions. Equal amounts of urea added to the rations induced similar increases in nitrogen retention.

In all experiments urea increased the digestibility of the rations.

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WOOL FIBER MEASUREMENTS

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THE various methods of measuring the physical properties of wool were developed primarily as aids in standardizing the visual grading of wool in the world markets. During recent years these methods have also been used in attempts to evaluate individual animals in selection programs designed to aid the practical breeder.

Burns (1930) summarized the literature on methods of measuring length of staple, length of fiber, crimp, strength, elasticity, diameter and density as well as luster, structure and purity. He indicated that Daubenton in 1777 was the first to mention the determination of wool fiber diameter with the microscope. Burns also pointed out that several workers including Doehner and Kronacher modified the microscope method and measured the projected magnified image on a screen.

Hill (1921) described the use of a machinist's caliper in measuring the diameter of wool fiber. Hardy (1935) described a practical method of preparing cross-sections of wool fibers for measurement of the diameter and later (1939) described two methods for estimating fineness and cross-sectional variability of wool; the count method and the rapid comparator method. His rapid comparator method, making use of projected images of the unknown sample and of samples with known average diameter and variation, has become the standard method of studying variation in fiber diameter.

Burns (1930) also reported that the optical refraction instrument developed by Ewles of Leeds University is satisfactory for medium and coarse wools, but not satisfactory for fine wools.

Gonsalves (1947) described a method for measuring the diameter of the fiber by using an instrument he called a vibrascope. The measurement of the diameter of fibers with this apparatus is based upon the principle that $D^2=\frac{K_2}{V}$ where D is the diameter, V is the frequency at which the fiber has its maximum vibration and K is the constant of the instrument.

Dart and Peterson (1949) using a similar type instrument have shown that by varying either the frequency, tension, or length, the diameter of a fiber can be measured providing two of these variables are held constant.

The apparent simplicity and ease of measuring the diameter of fibers with a vibrascope led us to construct a similar instrument in this laboratory. This vibrascope was developed for use in evaluating fleeces of individual animals in a selection program designed to improve the quality of wool.

Description of the Apparatus

This apparatus is similar to the one described by Thorsen (1951). It is essentially an audio oscillator model 2013 (purchased from Hewlett Packard Company, Palo Alto, California) attached to a 2-inch permanent magnet speaker with a resistance of 3.2 ohms. This type of

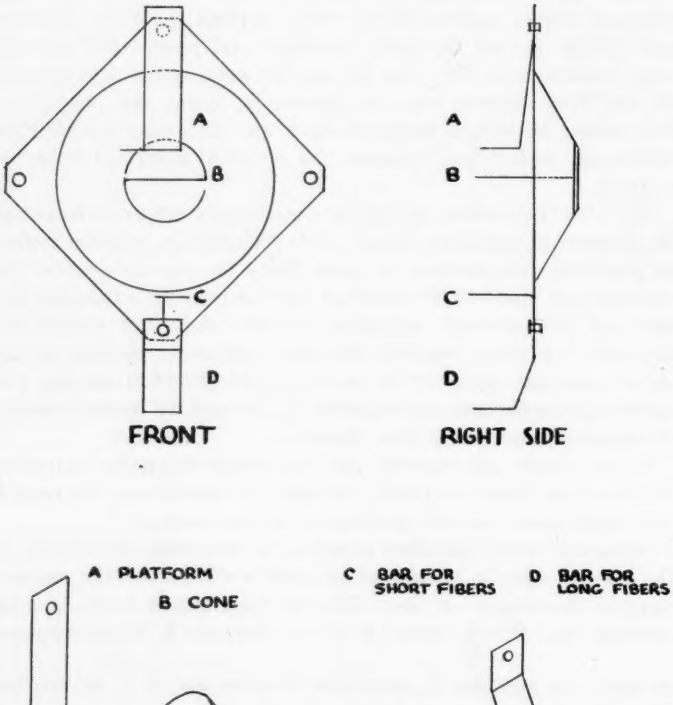

Figure 1. Details of the vibrascope.

speaker may be purchased at any radio shop at a cost of $3 to $5. The set-up of the apparatus is shown in figure 2.

The vibrascope is constructed as shown in figure 1. The platform "A" is attached to the upper edge of the speaker for attaching the wool fiber. The cone shaped vibrator "B" is made of #18 copper spring wire and is fastened to the speaker cone with Duco cement. Bar "D" is attached to the lower edge of the speaker and is exactly

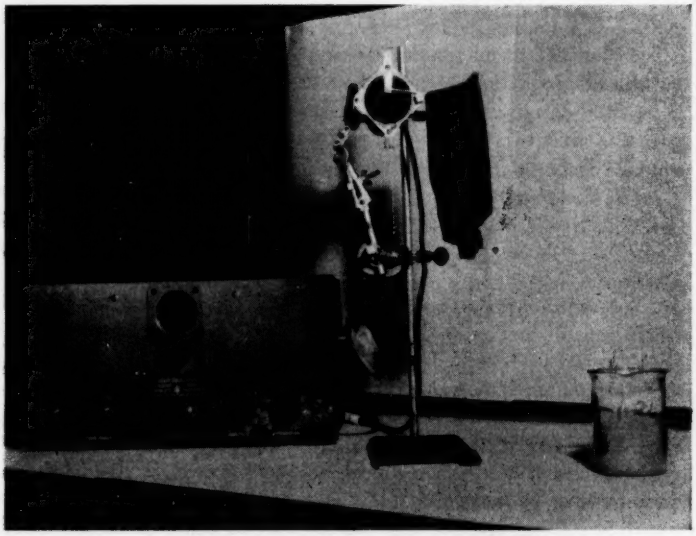

Figure 2. Photograph of the vibrascope.

6 cm. from "B." "C" is attached similarly to "D," but is exactly 3 cm. from "B." A magnifying lens is used for the magnification of the vibrating fiber. A piece of black cloth is used for a background as shown in figure 2.

Weights of 50, 150, 200, and 600 mg. are used. Shipping tag wire or other wire of the same diameter has been found convenient for making the different weights. The weights are made into a coil by winding the wire around a 6 mm. glass stirring rod.

It has been found convenient in this laboratory to attach one end of the wool fiber to a toothpick with a drop of collodion. The toothpick with the wool fiber is stuck into a beaker of sand and allowed to dry.

Ten or more fibers are prepared in this manner from one sample of wool. With the aid of the toothpick, the desired weight is then attached to the loose end of the wool fiber and the fiber is placed on the vibrascope for the determination of the frequency at which the maximum vibration is obtained.[1] For very short fibers, the 50 mg. weight is used with a 3 cm. vibrating fiber length. For longer fibers the 200 mg. weight with a 6 cm. vibrating fiber is used.

Calculation and Checking the Vibrascope

The diameter in microns of the wool fiber can be calculated from the following equation:

$$(1)\quad D^2=\frac{T\times 980\times 10^8}{L^2V^2d\times 3.1416}$$

Where D is the diameter; T is the tension in grams; d the density (density of wool is 1.3); L is the length in cm. of the vibrating fiber; and V is the frequency in cycles per second. In equation (1) the values of T, L, and V can be varied and are easily measured in the laboratory.

If T is 50 or 200 mg., and L is 3 cm. or 6 cm. respectively then;

$$(2)\quad D=\frac{11{,}546}{V}\text{Microns.}$$

From equation 2 the value for D can be determined for the different frequencies and put in a table form at intervals of 2 to 3 frequencies. The 200 mg. weight with a 6 cm. vibrating fiber is the weight most frequently used. With short fibers, the 50 mg. weight and a 3 cm. vibrating fiber is used.

If T is 200 mg. and 800 mg. and L is 3 cm. and 6 cm. respectively and the frequency obtained at maximum vibration is divided by 2, equation 2 is still valid. These different values for T and L can be useful for checking the vibrascope. That is to determine whether the maximum vibration obtained at a particular frequency is the true vibration of the wool fiber, and not due to the harmonics of the vibrascope.

These harmonics occur with our instrument at a frequency of 200 and below. If the maximum vibration of the wool fiber occurs near these frequencies, the weight T should be increased or the length decreased and the maximum vibration determined at a higher fre-

[1] With the aid of the attached toothpick, the loose end of the wool fiber is wound two or three times around the desired coiled weight. The toothpick, with the wool fiber and weight is placed on the platform A. The fiber is suspended so that it touches the cone B and bars C or D depending on the length of the fiber. The frequency is determined at the maximum vibration.

quency. This can be done without removing the wool fiber from the vibrascope by increasing T for the 3 cm. vibrating fiber to 200 mg. with a 150 mg. weight or increasing T for the 6 cm. vibrating fiber to 800 mg. with a 600 mg. weight. It is a good plan for the operator to check the diameter of wool fibers at different frequencies until he has become familiar with the performance of his vibrascope.

Method

In order to demonstrate the effectiveness of this method in measuring differences between individual sheep in both average diameter and variability some data are presented in table 1. The fleeces included in this sample were selected to show both extremes in variability and in average diameter. The average standard deviation of fiber diameter calculated for individual sheep on measurements obtained by this method is 4.83. This average is based on the measurement of 30 fibers from each of 239 fleeces. This is slightly smaller but quite comparable to the average found by Bertone and Landbloom (1949) of 5.09 on 272 Corriedale fleeces.

Standard deviations have been obtained in this laboratory for 122 fleeces using the method of measuring cross-sections described by Hardy (1935). The average standard deviation based on measurement of 30 fibers from each of three positions is 4.67. It would appear that this method is quite effective in estimating differences in variability of individual fleeces. This method has been found to be more rapid than the method of preparing cross-sections of wool fibers and making individual measurements. Forty to 50 fibers may be measured in one hour. Also any method of measurement using cross-sections is always plagued with possible error due to failure to cut precisely at right angles to the center of the fiber.

Summary

A rapid, simple and accurate method has been presented for the determination of the wool fiber diameter. This method makes use of the audio oscillator and a vibrascope constructed from a "2" inch permanent magnet speaker. With this apparatus, the frequency is obtained at the maximum vibration of the wool fiber. The diameter of a vibrating wool fiber then can be calculated from the following equation:

$$D^2 = \frac{T \times 980 \times 10^8}{L^2 V^2 d \times 3.1416}$$

TABLE 1. REPRESENTATIVE DATA FROM VIBRASCOPE MEASUREMENTS IN MICRONS

Sheep Number	Shoulder (10 Fibers)		Side (10 Fibers)		Thigh (10 Fibers)		Total (30 Fibers)		Standard Deviation
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	
490	26.8	23–38	41.3	32–56	38.9	28–56	35.6	23–56	11.11
41	29.7	21–40	37.0	28–43	44.0	31–48	36.9	21–48	8.77
803	32.8	28–36	37.2	31–43	42.0	33–52	37.3	28–52	5.75
1,545	25.3	21–28	26.3	21–38	29.4	25–34	27.0	21–38	4.43
144	27.3	25–30	29.4	24–31	30.8	28–35	29.2	24–35	2.86
1,559	27.0	24–30	28.7	23–31	27.8	24–30	27.8	23–31	2.66
494	23.4	20–27	25.1	22–30	27.2	24–30	25.2	20–30	2.59

Where D is the diameter of the wool fiber in microns, T is the tension in grams: d is the density of the fiber; L is the length in cm. and V is the frequency in cycles per second.

This method has been found useful for evaluating the quality of individual fleeces in a selection program, designed to reduce variability in fiber diameter.

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DISTRIBUTION OF INTRAVENOUSLY INJECTED RADIOACTIVE PHOSPHORUS (P^{32}) AMONG SHEEP TISSUES [1]

ARTHUR H. SMITH,[2] MAX KLEIBER, ARTHUR L. BLACK, JACK R. LUICK, ROBERT F. LARSON and WILLIAM C. WEIR [3]

University of California [4]

THE use of artificially radioactive isotopes as tracers in mineral metabolism studies has been previously described in experiments with swine (Smith *et al.*, 1951). This paper reports the utilization of plasma inorganic phosphorus (as traced by radioactive phosphorus) by the soft tissues of sheep at different ages, and at different times after injection of the tracer.

Method

Three groups of sheep of different ages (approximately one, four, and ten months) were selected from the Animal Husbandry flock. A description of these animals is given in table 1. An isotonic buffered solution, containing P^{32} labeled sodium phosphate, was injected intravenously. In the larger animals, an intravenous catheter was installed in the jugular vein for the injection (Ralston *et al.*, 1949). In the smaller animals where this was not possible, a bleeding needle with the catheter attached was used to locate and penetrate the vein. The syringe containing the radioactive solution was then connected to the free end of the catheter, and the drawing back of blood at the beginning and end of the injection was used to check the proper position of the needle for the injection. This flexible connection prevented the previously encountered difficulty, when manipulation of the directly connected syringe would force the needle on through the vein, the solution then being injected extravenously.

The animals were sacrificed by exsanguination at various times after injection. The desired tissues were removed, processed, and analyzed as previously described (Smith *et al.*, 1951).

In the course of these experiments some information, incidental to the tracer work, was collected on the tissue composition of sheep of different ages. Since these data are of interest in themselves, a sum-

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TABLE 1. DESCRIPTION OF EXPERIMENTAL ANIMALS

	One Month Old			Four Months Old						Ten Months Old					
Expt. No.	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15
Breed [1]	R-M	R-M	R-M	H	S	R-M	R-M	R-M	R-M	R	R	R-M	R-M	R-M	R-M
Sex	♀	♀	♀	♀	♀	♂	♂	♂	♀	♂	♂	♂	♂	♂	♂
Time killed (hrs. post-inj.)	1	6	24	½	1	3	6	24	48	1	4	8	24	48	72
Age (days)	31	28	34	97	92	132	130	127	125	293	294	295	288	296	295
Body weight (kg.)	10.7	12.7	6.6	14.8	24.1	15.0	16.4	18.2	13.9	45.5	72.7	46.5	45.3	51.4	53.6
Dose (mc P^{32}) [2]	1.9	1.9	1.8	4.0	4.0	6.0	6.0	8.0	7.7	4.4	4.4	4.4	4.4	4.4	4.4

[1] H=Hampshire; R=Rambouillet; R-M=Rambouillet Merino cross; S=Suffolk.
[2] 1 mc=1 millicurie=2.22×10^9 radioactive disintegrations per minute; measurements of radioactivity in the tissue are given in microcuries (μc); 1 μc=0.001 mc.

TABLE 2. COMPOSITION OF SHEEP TISSUES AND SIZE OF ORGANS

	One Month Old				Four Months Old				Ten Months Old			
	Actual Weight (gms.)	Relative Weight (gm./kg.)	Dry Matter (%)	Phos. Conc. mg.P/gm. Dry	Actual Weight (gms.)	Relative Weight (gm./kg.)	Dry Matter (%)	Phos. Conc. mg.P/gm. Dry	Actual Weight (gms.)	Relative Weight (gm./kg.)	Dry Matter (%)	Phos. Conc. mg.P/gm. Dry
Biceps muscle			29.1±2.4	9.3± .7			23.5±1.0	8.3± .4			26.9± .6	6.7± .3
Brain	53±2	5.7±1.0	19.1± .1	17.3±1.0	75±3	4.5± .3	20.5± .1	16.1± .2	90±4	1.8±.1	22.3± .3	14.7± .1
Gastrocnemius muscle			23.8±1.1	9.4± .7			20.6± .8	8.6± .2			24.9±1.0	7.6± .2
Heart	71±18	6.9± .7	24.0± .7	8.1± .7	99±6	5.8± .1	19.8± .5	10.2± .3	244±22	4.8±.2	21.3± .6	9.0± .4
Kidney	26±3	2.6± .2	20.1± .2	14.2±1.0	39±4	2.3± .1	20.5± .4	12.3± .2	84±4	1.7±.1	23.4± .7	11.0± .3
Liver	231±52	22.6±1.7	27.2± .2	15.4± .9	366±30	21.3± .5	26.6± .7	13.8± .3	816±58	16.2±.7	30.5± .6	14.3± .9
Lungs	162±39	15.7±1.4	19.5± .2	14.2± .9	229±22	17.6±1.0	18.8± .3	10.2± .9	613±53	12.0±.5	20.5± .3	10.5± .4
Lymph node			24.3± .1	15.4±1.6			19.4±1.2	17.8±1.6			20.2± .9	15.3±1.1
Ovary				9.3± .3								
Rumen muscle			22.2± .6	7.6±1.1			17.5± .5	6.6± .2			20.7± .4	5.2± .1
Spleen	26±5	2.6± .1	21.9± .2	15.3± .4	28±2	1.6± .1	21.4± .3	13.7± .4	81±4	1.6±.1	23.3± .4	13.5± .3
Thymus			21.2± .2	23.4±1.7							23.8±1.2	17.6±1.6
Tongue			24.4±1.0	10.3± .8							26.4± .3	6.2± .4
Testicle					10±1	.6± .1	19.4±2.1	13.2±1.3	263±20	5.2±.3	14.8± .4	13.0± .4
Body weight (kg.)	10±2				17±1				51±4			

mary of the total phosphorus content and dry matter (%) of the tissues analyzed, and some of the organ weights, are presented in table 2.

The specific activities (μc P^{32} per mg. phosphorus) of the tissues were calculated, and standardized as to body weight and dosage:

$$\text{standard specific activity} = \frac{\mu\text{c } P^{32}/\text{mg. phosphorus}}{\text{mc } P^{32} \text{ injected/kg. body weight}}$$

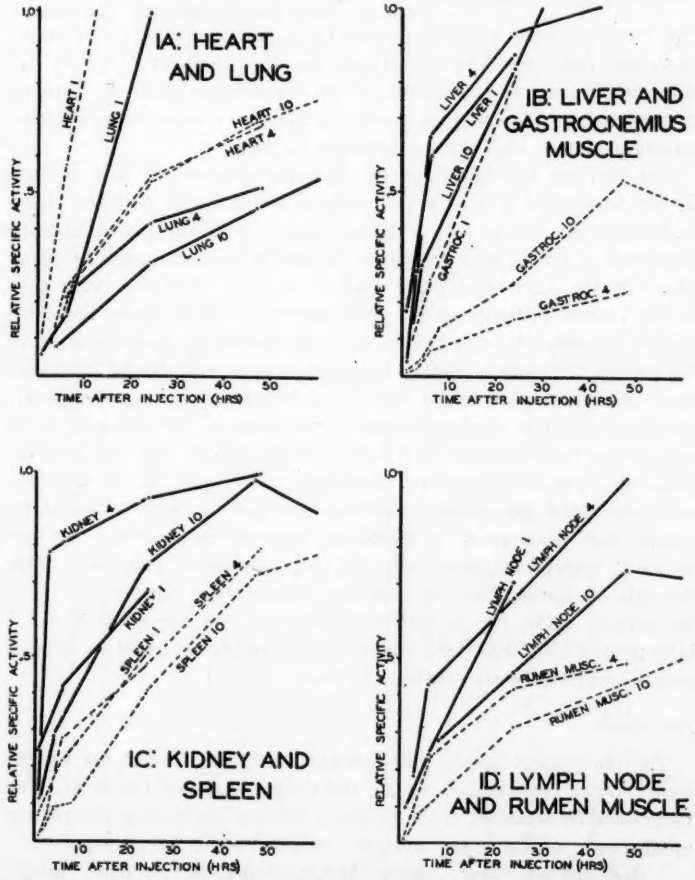

Figure 1. Relative specific activities of sheep tissues of different ages (one, four and ten months) following intravenous injection of radioactive phosphate (P^{32}).

This standard specific activity is proportional to the amount of the injected dose retained by the tissue. A summary of the standard specific activities of the tissues analyzed is given in table 3.

Since the animals were of different ages, and thus not in a similar physiological condition, the specific activities of the tissues were also calculated in terms of the plasma inorganic phosphorus:

$$\text{relative specific activity} = \frac{\text{specific activity tissue phosphorus}}{\text{specific activity plasma inorganic phosphorus}}$$

The relative specific activity removes the apparent effect of other major processes (such as bone formation) on the phosphorus uptake by the soft tissues, and is an index of the phosphorus metabolic activity of the tissues. The relative specific activities of some representative tissues analyzed are shown graphically in figure 1.

The decrease in relative specific activities observed at later periods in the experiment is unexpected, since it would imply that the tissue exchanges phosphorus with a source having a lower specific activity than that of the plasma phosphate. It has been shown that the phosphate in the interstitial tissue fluid is in rapid exchange with that of the plasma (Kleiber *et al.*, 1950) and thus should have the same specific activity. It may result from net losses in phosphorus from the tissues, particularly of the chemical fractions with greater exchange rates (i.e., those with higher specific activities). It seems more likely, however, that this decrease results from some of the phosphorus of the plasma trichloroacetic acid filtrate being organic. In such a situation, this organic phosphorus probably would not be in exchange with the tissue phosphorus, and also the specific activity would be falsely high since all of it would be "counted radioactive," but not all of it determined chemically by the colorimetric procedure. This decrease in specific activity was not considered a serious defect to the present study, but in such cases where it was important (e.g., at later periods after injection) the inorganic phosphorus could be isolated and determined by the method of Delory (1938).

Discussion

The phosphorus uptake rate (extent of uptake during the experiment) varies considerably among the tissues analyzed (table 3). The tissues can be arranged in the following order of decreasing phosphorus uptake rate, which is an "average" of the various age groups:

> Bile, thymus, liver, tongue, kidney, heart, lymph node, spleen, lung, rumen muscle, testes, biceps muscle, gastrocnemius muscle, and brain.

TABLE 3. STANDARD SPECIFIC ACTIVITY OF TISSUES

$\mu c\ P^{32}/mg\ P$ / mc P^{32} injected/kg. body weight

	One Month Old			Four Months Old						Ten Months Old					
Expt. No.	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15
Hours, post-inj.	1	6	24	½	1	3	6	24	48	1	4	8	24	48	72
Plasma phosphate	2.88	.95	.31	15.68	16.02	3.69	1.94	.86	.71	17.68	4.78	2.27	1.18	.76	.63
Biceps muscle	.68	.38	.38	.25	.15	.09	.11	.21	.28	.33	.22	.16	.21	.40	.28
Bile	.22	...	...	...	.21	.34	1.87	1.34	1.00	.29	.90	1.67	1.60	1.24	.86
Brain	.01	.02	.04	.02	.01	.02	.02	.03	.03	.01	.02	.04	.03	.04	.06
Gastrocnemius muscle	.15	.26	.25	.19	.14	.06	.14	.13	.16	.20	.16	.31	.30	.41	.25
Heart	.31	.55	.54	.32	.33	.31	.46	.46	.49	.46	.60	.60	.63	.52	.50
Kidney	.69	.40	.21	1.88	2.49	2.88	1.57	.80	.71	2.08	1.35	...	.88	.74	.51
Liver	.49	.59	.27	.37	.71	1.09	1.28	.80	.72	1.09	1.45	1.06	.98	.96	.66
Lung	.16	.16	.31	.43	.31	.33	.42	.36	.36	.43	.37	.38	.36	.35	.38
Lymph node	.27	.22	.22	...	.56	.58	.84	.57	.69	.86	.66	.63	.54	.56	.44
Ovary	...	.54	.74	...	...	...	...	...	...	...	...	...	...	...	...
Rumen muscle	.16	.13	...	.31	.27	.32	.45	.36	.35	.23	.37	.29	.37	.33	.35
Spleen	.21	.21	.16	.26	.28	.33	.54	.42	.56	.40	.44	.23	.49	.55	.51
Thymus	.25	.30	.40	...	...	...	...	...	...	.53	.69	.64	.71	.74	.68
Tongue muscle	.25	.18	.44	...	...	...	...	...	...	.73	.90	.58	.70	.72	.57
Testes	...	...	...	...	...	.33	.51	.36	...	.18	.23	.24	.28	.40	.33

The "average" arrangement of the tissues with regard to phosphorus uptake rate is similar to that observed in swine (Smith *et al.*, 1951), although there is much more variation in the position of a particular tissue in the series at different ages. This may be partly due to a more variable age; the sheep being one, four, and ten months, whereas the swine were two, four, and eight months old. Generally the phosphorus uptake rate (relative specific activity) of the sheep tissues is higher than that of the swine tissues.

The pronounced age effect on the phosphorus uptake rate, which was observed in swine, is not apparent in the sheep. Although the phosphorus exchange of tissues of the young sheep are generally greater than those of the older ones, there is very little difference between the four- and ten-month old sheep. There is very little difference in phosphorus exchange rate of the thymus, liver and spleen between any of the three age groups.

In the liver, the youngest sheep have the highest activity at periods soon after the injection, and the lowest at longer periods. This reversal suggests that different processes are involved at the different ages.

There were some definite differences in organ size and tissue composition between the swine and sheep. The relative weight of the sheep organs was generally, but rarely statistically significantly, larger than those of swine. The one exception was the liver, in which case the swine exceeded sheep in organ weight. The sheep tissues generally had a greater dry matter and phosphorus content. The exception was the phosphorus content of the heart muscle in which case swine exceeded sheep. In no other tissue did the swine have a higher phosphorus content than sheep in more than one of the three age groups.

Summary and Conclusions

The distribution of intravenously injected radioactive phosphate in the tissues of sheep of different ages, and at different times after injection is reported. The tissues of sheep can be listed in the following order of decreasing phosphorus uptake rate:

Bile, thymus, liver, tongue, kidney, heart, lymph node, spleen, lung, rumen muscle, testes, biceps muscle, gastrocnemius muscle, and brain.

The phosphorus uptake rates of sheep tissues are generally greater than previously noted for corresponding swine tissues. The effect of age on the phosphorus uptake rate is less pronounced in sheep between four and ten months of age than in swine.

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PITUITARY ACTIVITY OF SHEEP IN RELATION TO THE BREEDING SEASON

W. G. KAMMLADE, JR., J. A. WELCH, A. V. NALBANDOV and H. W. NORTON

University of Illinois [1]

RECENTLY considerable interest has been shown in the possibility of increasing the prolificacy of sheep. A variety of means has been employed experimentally to cause sheep to breed out of season. Cole and Miller (1933) were the first to demonstrate that anestrus ewes may be caused to conceive by appropriate hormone treatments. These and subsequent investigators have found this technique somewhat inefficient since, in spite of a high proportion of ewes ovulating, the resulting lamb crop is low. Hart (1950) subjected ewes to a regularly maintained rhythm of light and dark and was able to cause "out of season" breeding. Yeates (1949) found that in Suffolks the breeding season started some ten to 14 weeks after the longest day, and similar results were obtained by Hafez (1951). The seasonal breeding behavior of sheep can also be modified by genetic means (Hafez, 1951), and the possibility of prolonging the breeding season by genetic selection is now being investigated in this and other laboratories.

Various attempts to explain the seasonally polyestrous breeding behavior of sheep have been made. During the non-breeding period ewes are sexually inactive, hence it seems logical to assume that the anestrous period is due to a decrease in the secretory activity of the pituitary and the onset of the breeding season is caused by an increase in pituitary activity (T. J. Robinson, 1951). Cole and Miller (1935) compared pituitary potency of sheep in different reproductive states and stated that pituitary potency did not vary significantly during the anestrous period, the estrus cycle, or pregnancy. Warbritten and McKenzie (1937) concluded from a study of pituitary cytology that variations in the rate of synthesis of the follicle-stimulating hormone may be the cause of the seasonal breeding behavior of sheep.

In view of these rather conflicting findings, it seemed important to assay the pituitaries of sheep for gonadotrophic and thyrotrophic potency and to correlate the findings with the morphology and histology of the reproductive organs and the thyroids and with the

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psychological behavior of ewes during the anestrous season and the estrual cycle.

Materials and Methods

One hundred and thirty black-faced crossbred western ewes which probably originated in Montana were purchased in June, 1950, in Kentucky. They had been wintered as lambs on roughage and very little grain, and were very thin when delivered. On June 19, they were weighed, ear-tagged, number branded, drenched with phenothiazine and started on the experiment. At this time they ranged in weight from 61 to 101 pounds, averaging 78.5 pounds.

In addition to grass and legume pasture, a mixture of 45 percent yellow corn, 45 percent whole oats, and 10 percent linseed meal by weight was fed at a daily rate of one pound per head throughout the course of the experiment. A salt and phenothiazine mixture was fed free choice. Under these conditions the ewes gained satisfactorily throughout the experiment.

To identify ewes in heat, at least three vasectomized rams were kept with the flock at all times and the flock was checked for heat twice daily.

On each of the following dates during the anestrous period, three randomly selected ewes were slaughtered: June 19, 22, 26, 29; July 3, 6, 10, 13, 17, 20, 24, 27, 31; August 3, 7, 10, 14, 17, 21, 24, 28, 31; September 5 and 7, 1950. During the experiment none of the animals showed heat until the last week of August. From August 28 to September 7 inclusive seven ewes showed heat; three of these were slaughtered on the fourth day of the cycle, one on the fifth, two on the seventh, and one on the sixteenth. Because of the increasing frequency with which heats were observed after August 31, that date was considered as the beginning of the breeding season. Between August 31 and October 12, 1950, four ewes were slaughtered on the 1st and 2nd days of heat, and three were slaughtered on the 3rd, 4th, 5th, 7th, 9th, 11th, 13th 15th, 16th, 17th days of the estrual cycle. The period immediately prior to, during, and after the day of heat was considered most critical endocrinologically; therefore ewes were slaughtered each day in this period but only on alternate days during the remainder of the cycle. When several ewes came into heat on the same day an attempt was made to space their slaughter dates so that they would be killed on different days of the estrual cycle. All of the ewes whose pituitaries were assayed were killed during their first cycle of the breeding season.

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To identify ewes in heat, at least three vasectomized rams were kept with the flock at all times and the flock was checked for heat twice daily.

On each of the following dates during the anestrous period, three randomly selected ewes were slaughtered: June 19, 22, 26, 29; July 3, 6, 10, 13, 17, 20, 24, 27, 31; August 3, 7, 10, 14, 17, 21, 24, 28, 31; September 5 and 7, 1950. During the experiment none of the animals showed heat until the last week of August. From August 28 to September 7 inclusive seven ewes showed heat; three of these were slaughtered on the fourth day of the cycle, one on the fifth, two on the seventh, and one on the sixteenth. Because of the increasing frequency with which heats were observed after August 31, that date was considered as the beginning of the breeding season. Between August 31 and October 12, 1950, four ewes were slaughtered on the 1st and 2nd days of heat, and three were slaughtered on the 3rd, 4th, 5th, 7th, 9th, 11th, 13th 15th, 16th, 17th days of the estrual cycle. The period immediately prior to, during, and after the day of heat was considered most critical endocrinologically; therefore ewes were slaughtered each day in this period but only on alternate days during the remainder of the cycle. When several ewes came into heat on the same day an attempt was made to space their slaughter dates so that they would be killed on different days of the estrual cycle. All of the ewes whose pituitaries were assayed were killed during their first cycle of the breeding season.

As soon as the pituitaries became available they were placed individually in small, numbered, screw-cap vials, frozen within 40 minutes after the animal was killed and kept frozen until used. The thyroid glands, uteri, and ovaries were removed and examined as soon as possible after slaughter. If examination of the ovary indicated recent ovulation the oviducts and uteri were flushed to determine the presence of eggs. Each ovary was described and a record made of the number and size (diameter) of the follicles and corpora lutea present. The thyroid glands were cleaned of extraneous tissue and weighed to the nearest tenth of a gram.

After all 110 animals used in the study were slaughtered, the anterior lobe of each pituitary was assayed individually for the thyrotrophic and gonadotrophic hormone content in two-day old male Leghorn chicks using the procedure described by Robinson (1951). A preliminary dosage trial suggested that a total of 15 mg. of sheep anterior pituitary powder suspended in 4 cc. of distilled water given in eight equally spaced doses over a four-day period would produce a satisfactory response in the testis and thyroid weights of the assay animals. The dosage of pituitary powder was raised to 25 mg. in assay series II because the 15 mg. dose used in series I failed to reveal differences in thyrotrophic hormone content. The dosage level was reduced in subsequent series for the reason noted under results.

Three chicks were used to assay each gland. As it was impractical to assay more than 36 glands at one time, from 12 to 36 pituitaries were assayed simultaneously. All the glands assayed at one time were considered to constitute an assay series. Since it appeared probable that the pituitary potency of anestrous and cycling sheep would differ, the pituitaries were sampled so that both seasons were well represented in each assay series except the fourth. Each series permits comparisons unaffected by genetic or seasonal differences between series in sensitivity of the assay animals, variation in dosages, procedure, and other factors, including any secular change in pituitary potency during storage. The numbers of pituitaries, dosage used, slaughter dates and days of the cycles represented in each assay series are shown in table 1.

To reduce errors introduced by the time required to kill the chicks by ether and to collect their glands, the assay animals in each series were divided at random into three blocks. A block was made up of one chick from each treatment in an assay series. Subsequent statistical analysis showed that blocks were not an important source of experimental error. Chicks were weighed immediately after death to permit accounting for variability due to chick size.

Results

Gonadotrophic Potency of Pituitaries

Sixty-three pituitaries from anestrous ewes and twenty-four pituitaries from cycling ewes were assayed individually.

Contrary to expectation the potency of pituitaries during the non-breeding period was found to be high and rather constant (figure 1, table 2). The results obtained in series I, II and III, involving dosages of 15 or 25 mgs. of pituitary powder per chick, made it seem possible that the dosages used had caused maximal responses of the end organs thus precluding the possibility of finding a trend in hormone output during the anestrous period. For this reason dosages of 4 and 8 mgs.

TABLE 1. SLAUGHTER DATES AND DAYS OF ESTRUS CYCLE REPRESENTED BY EWES ACCORDING TO ASSAY SERIES

Assay Series	No. of Glands Assayed	Total Dose per Chick for 4 Day Period	Non-Breeding Season	Days of Cycle [2]
		(mgs)		
I	12	15	June 19, July 3, 17, 31, August 14, 28	1, 3, 7, 11, 15, 17
II	24	25	June 22, 26, 29, July 6, 10, 13, 20, 24, 27, August 3, 7, 10, 17, 21, 24, 31, September 5, 7 [1]	2, 4, 5, 9, 13, 16
III	36	15	June 19, 22, 26, 29, July 3, 6, 10, 13, 17, 20, 24, 27, 31, August 3, 7, 10, 14, 17, 21, 24, 28, 31,[1] September 5, 7 [1]	1, 2, 3, 4, 5, 7, 9, 11, 13, 15, 16, 17
IV	15	8	June 19, 26, July 3, 10, 17, 24, 31, August 3,[1] 7, 14, 21, 28, 31,[1] September 5,[1] 7 [1]	
IV	14	4	June 19, 26, July 3, 10, 17, 24, 31, August 3,[1] 7, 14, 21, 28, September 5,[1] 7 [1]	
IV	Pooled anestrous pituitary powder	50	Pooled sample of randomly selected anestrous pituitaries	

[1] Denotes ovulation unaccompanied by heat.
[2] Days of cycle extended from August 31 to October 12, 1950.

were used in series IV, causing testicular responses below those obtained on the higher doses. Regardless of dosage, pituitary potency was found to remain unchanged throughout the anestrous period.

During the breeding season the day of heat was designated as day

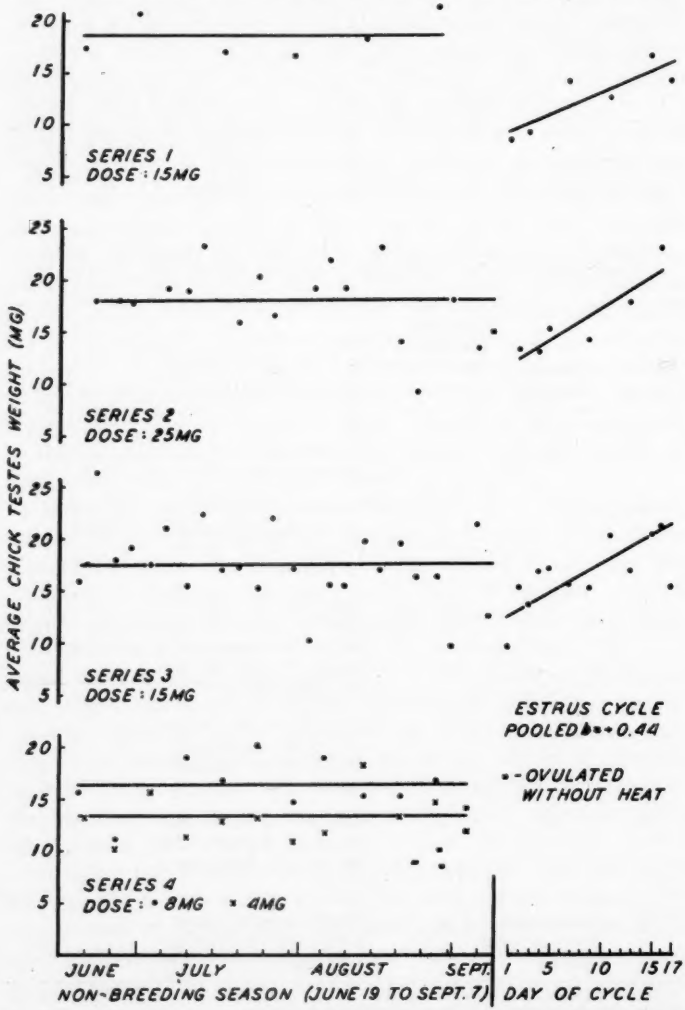

Figure 1. Average levels of gonadotrophic hormone in anterior pituitaries of sheep during the anestrous period and the estrus cycle.

one of the cycle. The glands from cycling ewes were assayed in three series simultaneously with the glands from anestrous animals (table 1). Statistical analysis of the data showed a linear increase in gonadotrophic potency of pituitaries from the first to the 17th day of the cycle (figure 1). Since the slope of the regression lines in the three series were very similar, the results obtained in them were pooled. The combined regression coefficient was $+0.44 \pm 0.083$ mgs. of chick testis per day of cycle.

On the first and second days of the cycle, when the ewes were in heat, the gonadotrophic hormone potency was lowest. Throughout

TABLE 2. AVERAGE RESPONSE OF CHICK TESTES AND THYROID TO VARIOUS DOSAGES OF PITUITARY POWDER

Assay Series	Dosage	Average Chick Testes Weight			Average Chick Thyroid Weight		
		Non-Breeding Season	Estrual Cycle	Controls	Non-Breeding Season	Estrual Cycle	Controls
	(mgs)	(mgs)	(mgs)	(mgs)	(mgs)	(mgs)	(mgs)
I	15	18.6	12.6	8.2	3.6	3.5	2.2
II	25	18.0	16.1	9.4	3.6	3.9	1.6
III	15	17.5	16.4	9.3	3.4	2.8	1.9
IV	4	13.2	...	9.2	...	...	1.5
IV	8	16.3	...	9.2	...	...	1.5
IV	50	28.6	...	9.2	...	...	1.5

the cycle the potency increased linearly until a maximum was reached on the 16th or 17th day. In every series the average pituitary potency during the estrual cycle was significantly lower than the anestrous average but the maximum potency during the cycle approximated the anestrous average. A comparison of control chick testes weights and testes weights of chicks treated with pituitary powder representing days one and two of the estrual cycle indicated an almost negligible gonadotrophic potency during the first stages of the cycle. These results are similar to those obtained by Robinson and Nalbandov (1951) for the changes in the gonadotrophic potency of pituitaries during the estrus cycle of swine.

Ewes which ovulated without heat prior to the onset of the breeding season were considered in a category separate from those classed as belonging to either the non-breeding or breeding groups. The gonadotrophic potency of the glands from these ewes was within the potency range of pituitaries from cycling ewes.

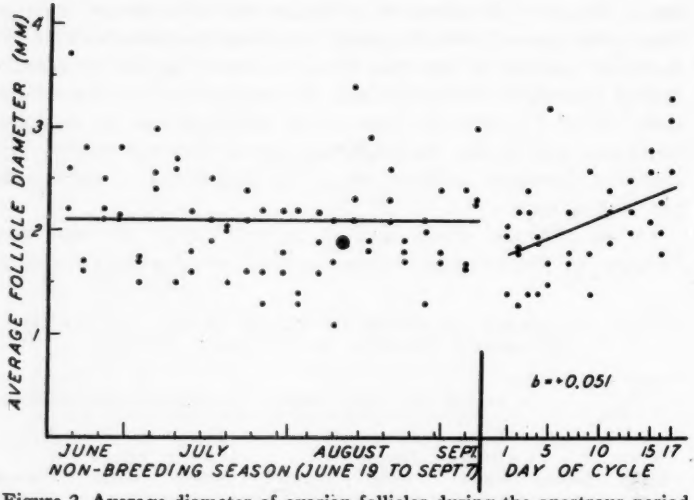

Figure 2. Average diameter of ovarian follicles during the anestrous period and the estrus cycle.

Thyrotrophic Potency of Pituitaries

There was no significant change in the thyrotrophic hormone potency of the pituitary in either the cycle or the non-breeding period nor was there a difference between these two periods. There was no significant difference in the weight of the thyroid glands between the ewes in the two stages, nor any correlation between the thyrotrophic potency

TABLE 3. COMPARISON OF FOLLICLE NUMBERS AND SIZES IN SHEEP DURING THE BREEDING AND NON-BREEDING SEASONS

	No. of Ewes	Av. No. of Follicles (1 mm. and Over in Diameter) per Ewe	Av. Diameter of Follicles	Av. Diameter of Largest Follicle Present
			(mm.)	(mm.)
Anestrous	72	18.96 [1]	2.07	5.53
Standard error		0.826	0.059	0.108
Standard deviation		7.01	0.50	0.92
Estrus cycle	38	26.18 [1]	2.10	6.00
Standard error		2.111	0.080	0.200
Standard deviation		13.01	0.49	1.36

[1] Difference between anestrus and estrus significant at 1% level.

of the pituitaries and the weights of the thyroids of the ewes in which these data were compared.

Ovarian Morphology

Although ovarian morphology was not of primary interest in this experiment our results (table 3, figure 2) are generally in agreement with the findings of earlier workers with regard to ovarian activity during the non-breeding season. Taking into consideration only follicles 1 mm. in diameter or larger, no significant change in number or size of follicles was found during anestrous. It is of interest that there is no difference in either the average diameter of all follicles or the diameter of the largest follicle between the anestrous period and the breeding season. The only highly significant difference found between the two stages was in the total number of follicles; the ewes during the breeding season had significantly more follicles than those in anestrous. It should be noted that neither morphologically nor histologically can the anestrous ovary be called inactive.

During the estrus cycle there appears to be no relation between the number of follicles and the stage in the cycle, but the regression of average follicle diameter on day of cycle was highly significant ($b=+0.051\pm0.014$ mm. per day) (figure 2). Thus, as both increase through the cycle, there is a correlation between pituitary potency and average follicle diameter. However, the deviations of the chick testes weights and the follicle diameters from their respective regression lines are not significantly correlated. This is puzzling, as animals having pituitary potency above average would be expected also to exceed the average follicle diameter.

Prior to the onset of the breeding season (August 31) 66 anestrous ewes were killed; none of these had shown heat and only one had ovulated (August 3). From August 31 to September 7 six out of nine ewes killed had ovulated without coming into heat.

Discussion

Contrary to the generally accepted assumption (T. J. Robinson, 1951), pituitaries contain more gonadotrophic hormone during the anestrous period than they do during estrus cycles. Unfortunately the assay method employed did not distinguish between the two components of the gonadotrophic complex. On the basis of the results obtained it is interesting to speculate on a possible interpretation of the causes of the anestrous period in sheep.

It does not seem probable that the pituitary forms gonadotrophic

hormone during anestrus but does not release it. The presence of many follicles in the ovaries of anestrous ewes as large as those found in cycling ewes shows that ovaries during anestrus are not inactive. Furthermore, some of the large follicles found in anestrous ewes can be ovulated by the injection of luteinizing hormone (LH) (Nalbandov, unpublished). These facts suggest that the ovaries of anestrous ewes are being stimulated by pituitary secretions but the stimulation resembles the effects produced by follicle stimulating hormone (FSH) alone rather than that of both components. Greep *et al.* (1942) state that FSH alone, while capable of causing follicular development, does not cause estrogen secretion in the absence of LH. This may be true in anestrous sheep for, despite the presence of large follicles, the uterine epithelium is distinctly castrate in type. The anestrous period is also characterized by the absence of heat periods due to absence of estrogen.

Follicular size and gonadotrophic potency were found to be correlated during the estrus cycle. This accords with the idea that the bioassay used in this study actually measures the rate of hormone secretion and argues indirectly against the possibility that the pituitary does not release its secretions during the anestrous period.

On the basis of these findings it is suggested that the non-breeding season of sheep is caused by a shift in the ratio of FSH to LH secreted by the pituitary, during anestrus primarily FSH being secreted (as shown by ovarian activity) but very little if any LH (as shown by uterine histology, absence of heats, absence of ovulations, induction of ovulations by exogenous LH).

It is also of interest to speculate on the connection between the observation of Yeates that the onset of the breeding season follows decreasing light duration and the finding that pituitary activity is higher during anestrus than it is during the breeding season. It is usually accepted that the pituitary secretes increased amounts of gonadotrophic hormone with increasing exposure of the animal to light. Since the pituitary secretes more than the optimal amounts of hormone in the anestrous period, reduction in light may bring the hormone output to a level at which the FSH/LH ratio is more nearly compatible with normal reproductive function. As light increases toward the end of the breeding season the pituitary again responds by increased production of hormone (probably FSH), the ratio between FSH and LH is changed and the anestrous period begins.

Summary and Conclusions

The total gonadotrophic potency of pituitaries during the non-breed-

ing season of sheep is uniformly higher than during the breeding season There is a distinct and significant drop in gonadotrophic activity at the time of the first heat period of the breeding season. During the cycle there is a steady rise in potency from the day of heat to the 16th or 17th day of the cycle when the hormone level reaches a maximum during the estrus cycle.

Using average follicle diameter or diameter of largest follicle as the criterion, ovaries are as active during the non-breeding season as during the breeding season, but there are significantly more follicles during the breeding season than during the anestrous period (26.2 ± 2.1 vs. 19.0 ± 0.83). The equality of diameters, and the presence of appreciable numbers of follicles during anestrus is taken as evidence that some gonadotrophic hormone is being secreted by the pituitary during the non-breeding season.

The ovarian follicles present during anestrus probably do not secrete estrogen as heat does not occur during that period and the uterine endometrium appears atrophic.

On the basis of these findings it appears that anestrus is due to an imbalance between FSH and LH. The observed high gonadotrophic potency during anestrus is thought to be due to an increased production of FSH with LH remaining unchanged or dropping in amount.

The possible relationship between the rate of secretion of gonadotrophic hormone and light and the relation of both these factors to the breeding season is discussed.

These observations contradict the assumption that the non-breeding season is due to inactivity of the anterior lobe of the pituitary.

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THE EFFECTS OF DIETHYLSTILBESTROL, TESTOSTERONE, AND PROGESTERONE ON GROWTH AND FATTENING AND CERTAIN CARCASS CHARACTERISTICS OF WESTERN LAMBS [1,2]

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University of Wisconsin

SUBCUTANEOUS implantation of stilbestrol pellets has been shown to increase rate of gain in feeder lambs (Andrews *et al.*, 1949 and Jordan, 1950), in 21 to 42 day old suckling lambs on pasture (Perry *et al.*, 1951), and in beef heifers (Dinusson *et al.*, 1950). However, in suckling lambs, one to two months of age (Jordan and Dinusson, 1950) and in pigs (Dinusson *et al.*, 1951 and Woehling *et al.*, 1951), no significant differences were shown between treated and control animals.

An increase in feed efficiency by use of stilbestrol has been reported in beef heifers (Dinusson *et al.*, 1950), in beef steers (Andrews *et al.*, 1950) and in lambs (Andrews *et al.*, 1949 and Jordan, 1950). Dinusson *et al.*, 1951 found that control pigs required slightly more feed per 100 pounds gain than the stilbestrol treated pigs but Woehling *et al.*, 1951 found no significant difference between the control and treated groups of pigs.

Stilbestrol treated beef heifers (Dinusson *et al.*, 1950) and lambs (Jordan, 1950) were easier to keep on feed than were the control animals.

Stilbestrol has been found to cause carcass grades of the treated animals to be lower than controls in lambs (Jordan, 1950), in beef heifers and steers (Clegg *et al.*, 1951) and in boars (Pearson *et al.*, 1951) but not in barrows or gilts (Pearson *et al.*, 1951 and Woehling *et al.*, 1951). Andrews *et al.*, 1950 reported no effect upon carcass grade of beef steers and Dinusson *et al.*, 1950 found no effect in beef heifers.

Testosterone appeared to increase rate of gain and feed efficiency slightly in lambs (Andrews *et al.*, 1949) but no effect could be demonstrated in steers (Andrews *et al.*, 1950) or in beef heifers (Dinusson

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[2] The authors are grateful to Oscar Mayer and Company for their cooperation in making this study possible.

et al., 1950). The latter is at variance with the report of Bogart *et al.*, 1951, who noted rather marked effects in beef calves. Woehling *et al.*, 1951 found no significant effects of testosterone either on rate of gain or in feed efficiency of pigs.

More information is needed on the effectiveness of testosterone in lambs and there seems to be some justification for the study of another steroid hormone, progesterone, in view of the presumed beneficial effects of pregnancy on growth and fattening. Further, the suggestion that stilbesterol lowers carcass grade points to a need for more detailed carcass studies.

Two experiments involving 100 wethers and 100 ewes in each experiment were conducted in 1950 and 1951 to compare the effects of stilbestrol, testosterone and progesterone with controls on growth, fattening and feed efficiency as well as certain carcass characteristics.

Materials and Methods

The wether and ewe lambs in each experiment were lotted separately to test sex differences and sex-treatment interaction. The lambs within each sex were divided at random into five equal sub-groups, a sub-group consisting of two lots of 10 lambs per lot.

Experiment I

In experiment I a sub-group from each sex was placed in each of the following treatment groups: (C) control, (St.) stilbestrol [3]—one 12 mg. pellet, (T) testosterone [4]—one 15 mg. pellet, (Pg.) progesterone [5]—two 30 mg. pellets, and (E.) combination-wethers received St. and T. and ewes received St. and Pg. All pellets were implanted subcutaneously in the neck region at the beginning of the experiment.

The lambs were placed on a ration of alfalfa hay (14.0 percent protein), shelled corn and linseed meal. The lambs were hand fed with each lot receiving the same amount of feed daily. (Daily feed consumption was thus determined by the "poorest eating" group.) All feed given was weighed and feed refused weighed back so that total feed consumption per lot was obtained over the entire experimental period. When animals were removed from experiment, feed was prorated to the remaining animals. The percentage of hay in the ration was decreased from approximately 70 at the beginning of the

[3] Stilbestrol furnished by Wick and Fry, Inc., Cumberland, Indiana.
[4] Testosterone furnished by Ciba Pharmaceutical Products, Inc., Summit, New Jersey.
[5] Progesterone pellets prepared by Dr. Louis W. Busse of the School of Pharmacy, University of Wisconsin, Madison, Wisconsin.

experiment, to approximately 50 when the animals were on full feed. The average daily feed intake per lamb for the various groups were as follows: C. 3.11, St. 3.06, T. 3.12, Pg. 3.11 and E. wethers—3.06, ewes—3.11 pounds.

Each animal was weighed at the beginning of the experiment and at weekly intervals thereafter and removed from experiment the first weigh day on which it weighed at least 100 pounds, except that no animal was removed for slaughter until it had been on experiment for 34 days. Animals were taken off experiment at 100 pounds weight so as to have carcasses of comparable size for carcass studies.

Each carcass was given a grade and finish score within one-third of a grade by a federal grader.

For detailed carcass studies a sample was taken from each of five animals selected at random from each of the sub-groups of wethers. A transverse section was cut from the carcass just caudal to the 10th rib. By use of a power band saw this sample was smoothed to a thickness of one inch. The width of the sample was determined by lateral dissection through the ribs at the distal edges of the eye muscles (Longissimus dorsi) and parallel to the vertebral column. The entire sample was then weighed. The thickness of external (subcutaneous) fat was measured over the center of the left eye muscle. This external fat was then removed at a "natural" division between it and the connective tissue enveloping the eye muscles and weighed. The internal fat, known as overflow, on the inside surface of the ribs and lumbar vertebra was removed and weighed. The weight of the remainder consisting of bone, muscle and connective tissue was obtained by difference.

The specific characteristics studied were (1) rate of gain, (2) economy of gain, (3) length of time on experiment, (4) dressing percentage, (5) carcass grade, (6) carcass finish, (7) weight of external fat, (8) weight of internal fat, (9) thickness of external fat and (10) combined weight of muscle, bone and connective tissue.

Experiment II

The lambs were self-fed a ration of 40 percent chopped alfalfa hay, 55 percent ground shelled corn and 5 percent linseed meal throughout the experiment. During the interval of approximately three weeks, from the purchase of the lambs to the start of the experiment, each lamb was treated for external and internal parasites and vaccinated against enterotoxemia.

At the beginning of the experiment a sub-group of lambs from each

sex was placed on each of the following treatments: (C.) control, (St.) stilbestrol—one 12 mg. pellet of stilbestrol implanted as in experiment I, (St. 2) stilbestrol 2—one 12 mg. pellet implanted initially and a second pellet implainted 28 days later into each animal weighing less than 90 pounds, (T.) testosterone [6]—20 mgs. in aqueous alcoholic solution injected once weekly into each lamb under 90 pounds and (Pg.) progesterone [6]—20 mgs. in aqueous alcoholic solution injected once weekly into each lamb under 90 pounds. (The latter two hormones were injected in this experiment rather than implanted, as pellets to insure adequate absorption.)

The lambs were weighed weekly and removed from experiment as in experiment I.

The lambs were marketed over a period of several weeks at a local slaughter plant. Each lamb was given a live market grade and value by a packer-buyer at the time of the sale. For purposes of statistical analysis the following values were assigned to each grade: utility 0, commercial 3, good 6 and choice 9.

In computing the return from the lambs, a standard price for each grade was used for all lambs regardless of the time marketed. These standard prices were the actual averages of the selling prices received for all lambs within each of the different grades.

At the time of slaughter the seminal vesicles and ampulla of each wether and the largest follicle in the ovaries of each ewe were measured.

A carcass grade and a finish score were placed on each carcass to within one-third of a grade.

The length of the front shank bone (metacarpal) was measured by inserting a metal skewer between the metacarpal and the carpal bones on the front of the leg and measuring from that point to the longest point on the breakjoint.

A sample was taken from each carcass and prepared as described in experiment I except that the eye muscles were removed from the sample and weighed, which left a residue of bone and connective tissue. Certain additional measurements were made. Length and width of the cross section of eye muscle were taken on the carcass at the 10th rib. Width of the 11th thoracic vertebra was taken at the point of union of the 11th and 12th vertebrae. The height of the 11th vertebra including spinous process was measured at its anterior end.

For statistical treatment of the data the analysis of variance was used in both experiments. In addition, in experiment I an L.S.D. for each sex was used for testing differences between the "combina-

[6] Testosterone and progesterone furnished by Pitman-Moore Company, Indianapolis, Indiana.

tion" sub-groups and their respective controls. In experiment II the mean square for sex, treatment and interaction were calculated by use of individual degrees of freedom (see Snedecor, p. 406, section 15.4). Analysis of covariance was used for adjusting various characteristics for variability in the carcass weight. The fat-water relationship was studied by use of linear and curvilinear regression. Correlations between certain characteristics were calculated.

In a non-orthogonal design as used in these experiments where several treatments are compared to one control group, statements about probability may not be exact; hence, for more conservative estimates, probabilities between .02 and .005 were arbitrarily considered statistically significant and less than .005 highly significant.

In experiment II the characteristics studied were the same as 1–9 inclusive of experiment I with the following additions: (1) daily feed intake (held constant in experiment I), (2) market grade, (3) size of seminal vesicles, ampullae and follicles, (4) length of metacarpal, (5) vertebra size, (6) weight of eye muscles, (7) measurement of eye muscle, (8) percentage of water in the external fat and (9) amount of residue (bone and connective tissue).

Results and Discussion

The Effects of Stilbestrol

Results from implants of a single pellet of stilbestrol will be dealt with primarily in this section. The rate of gain was so rapid in the stilbestrol treated animals of experiment II that only 13 of the 40 lambs in the St. 2 group were actually below 90 pounds by the time the second pellet was to be implanted, or 28 days after the experiment started. The average rate of gain for these 13 animals, from the time of re-implantation to market weight was identical to that of comparable animals in the St. group, or .62 pounds daily per lamb. Hence it is believed that the action of stilbestrol is quite well portrayed by the "single pellet" groups and the data on the St. 2 groups are omitted from the tabulations.

Initial Weight and Days on Experiment. The average initial weight of the lambs in experiment I was 76 pounds. The treated lambs reached the final weight of 100 pounds in an average of 43 days as compared to 47 days for the controls. Length of time on experiment was not statistically different between treatments. In experiment II when all animals were kept on experiment from an average initial weight of 72 pounds until they reached the same final weight of 100 pounds, the treated lambs required an average of 46 days compared

to 71 days for the controls. This difference of 25 days was highly significant. Therefore, labor, housing facilities and capital invested were released sooner by the stilbestrol animals and in addition death losses were risked over a shorter interval of time.

Daily Feed Intake. In experiment I the lambs were hand fed and the feed intake was regulated so that treated and control animals were similar and therefore not analyzed, but in experiment II where lambs were self-fed the average daily feed intake (calculated on a lot basis) for stilbestrol treated lambs was 3.48 pounds per lamb compared to 3.21 pounds for the controls. This highly significant increase was evident for both ewes and wethers. There was no sex-treatment interaction.

Dinusson *et al.* (1950) found that the total feed consumed daily by

TABLE 1 .THE EFFECT OF STILBESTROL ON FEED EFFICIENCY

(Feed per 100 pounds gain)

	Experiment I		Experiment II	
Sex	Control	Stilbestrol	Control	Stilbestrol
Wethers	547	454	772	533**
Ewes	660	504*	778	544**
Averages	603	479*	775	539**

* Statistically significant difference from controls.
** Statistically highly significant difference from controls.

beef heifers was greater in the stilbestrol treated group than in the control group. They concluded that stilbestrol increased appetite.

Results obtained in experiment II with lambs are in accord with results obtained with beef heifers. However, Jordan (1950) found no significant difference between full fed stilbestrol treated lambs and controls when specifically tested for differences in average daily feed consumption.

Feed Required per 100 Pounds Gain. In experiment I the stilbestrol treated lambs required less feed per 100 pounds gain than did the controls. The difference in feed efficiency between the stilbestrol treated wethers and control wethers was not statistically significant (93 pounds of feed saved) but treated ewe lambs required significantly less feed per 100 pounds gain than the control ewes, a saving of 156 pounds. There was no significant sex-treatment interaction.

The amount of feed required per 100 pounds gain was significantly reduced by use of stilbestrol in experiment II (table 1); the amount required being 775 pounds of feed per 100 pounds gain for the con-

trols and 539 pounds for the stilbestrol treated animals. This represented a saving of 236 pounds of feed on 100 pounds gain. The results were similar in wethers and ewe lambs. Increase in feed efficiency by use of stilbestrol in these experiments is in agreement with Andrews *et al.* (1949), Dinusson *et al.* (1950) and Jordan (1950).

Rate of Gain. In experiment I the average rate of daily gain for the control lambs was .54 pounds and for stilbestrol treated lambs .66 pounds, a highly significant increase (table 2). Stilbestrol treated lambs made more rapid gains in experiment II than the controls—the controls averaging .43 pounds daily compared to .66 for the treated

TABLE 2. THE EFFECT OF STILBESTROL ON RATE OF GAIN

Sex	Experiment I		Experiment II	
	Control	Stilbestrol	Control	Stilbestrol
Wethers	.60	.68*	.45	.69**
Ewes	.48	.65**	.41	.64**
Average	.54	.66**	.43	.66**

* Significant.
** Highly significant.

animals. This increase was highly significant. There was no sex-treatment interaction in either experiment. Thus the rate of gain was increased significantly in both ewes and wether lambs in both experiments. This is in agreement with work reported by Andrews *et al.* (1949), Jordan (1950) and Terry *et al.* (1951).

Live Grade. Values for live grade were obtained only on lambs in experiment II. Statistical analysis failed to show a significant effect of stilbestrol on the live grade of the wethers, the values being 4.0 for the control and 3.6 for the treated, but the grade of the treated ewe lambs (3.2) was significantly lower than the control ewe lambs (5.4). Ewe lambs of the St. 2 group had a value of 4.8 which was not significantly lower than the control group. The apparent effects of stilbestrol on the live grade of ewe lambs, therefore, were not uniform.

Size of Seminal Vesicles, Ampullae and Follicles. At the time of slaughter measurements were made on length and width of the seminal vesicles and the diameter of ampullae of wethers and of the diameter of the largest follicle in ewes (table 3).

Analysis of the measurements showed a highly significant increase in both seminal vesicles and ampulla for the treated animals over the controls. Follicle diameter was markedly depressed in ewes receiving stilbestrol treatment.

TABLE 3. THE EFFECT OF STILBESTROL ON SEMINAL VESICLES, AMPULLAE AND FOLLICLES

Experiment II			
	Wethers		Ewes
Treatments	Seminal Vesicles (Product of 2 Dimensions in mm.)	Ampullae (Diameter-mm.)	Follicle (Diameter-mm.)
Control	100.4	3.2	5.8
Treated	327.5**	5.7**	1.5**

** Highly significant.

Dressing Percentage. A dressing percentage based on the warm weight of the carcass was calculated (table 4). The dressing percentage for stilbestrol treated animals was 0.9 percent less than for the controls in experiment I. This difference approached significance. In experiment II stilbestrol treated lambs (ewes or wethers) each had a highly significantly lower dressing percentage than the controls (3.2, and 2.6 percent). There was not a significant sex-treatment interaction in either experiment.

The nature of the difference in dressing percentage needs further analysis in the course of future experiments. A preliminary breakdown might compare differences in (1) shrink, (2) fleece, (3) pelt, (4) different parts of the viscera and (5) contents of different parts of the alimentary canal.

Carcass Grade. The carcass grade was significantly lower in the stilbestrol treated animals (table 5), being approximately a third of a grade lower than the controls in experiment I. The carcass grade of stilbestrol treated ewes, while averaging lower than the control ewes, was not statistically significant.

In experiment II the carcass grades of both ewes and wethers were significantly lower in the treated group than in the control group.

TABLE 4. THE EFFECT OF STILBESTROL ON DRESSING PERCENTAGE

	Experiment I		Experiment II	
Sex	Control	Stilbestrol	Control	Stilbestrol
Wethers	45.6	44.7	45.6	43.0**
Ewes	46.4	45.4	46.0	42.8**
Average	46.0	45.1	45.8	42.9**

** Highly significant.

The mean of the control group (5.3) was slightly above the grade of low good; the mean of the stilbestrol group was 3.5 and slightly below the grade of high commercial—the difference being approximately one-half grade lower for the stilbestrol treated animals.

Carcass Finish. Carcass grade and finish in lambs were highly correlated in experiment II. Over all animals the gross correlation between carcass grade and finish was 0.83. The correlation between carcass grade and finish was not calculated in experiment I.

TABLE 5. THE EFFECTS OF STILBESTROL ON CARCASS GRADE AND FINISH

Sex	Experiment I		Experiment II	
	Control	Stilbestrol	Control	Stilbestrol
	(Carcass Grade [1])			
Wethers	5.0	3.8*	4.8	3.3**
Ewes	5.1	4.6	5.7	3.8**
Average	5.0	4.2*	5.3	3.5**
	(Carcass Finish [1])			
Wethers	4.8	3.6*	4.0	2.9**
Ewes	4.8	4.4	4.8	3.4**
Average	4.8	4.0*	4.4	3.2**

[1] The following scores were assigned: Utility 0, commercial 3, good 6, and choice 9.
* Significant.
** Highly significant.

Stilbestrol treated lambs carried significantly less finish than the controls in experiments I and II. In experiment I, however, the effect did not show as being significant when ewes only were considered (treated, 4.4 as compared to control, 4.8). There was no sex-treatment interaction.

Length of metacarpal. It is to be remembered that these lambs were taken to a constant live weight of 100 pounds. The average length of the metacarpal was 108.2 mm. for the control animals and 108.0 mm. for the treated; further study of bone growth should be made where both control and treated animals are on experiment for the same interval of time.

Thickness of External Fat. In experiment I the stilbestrol treated wethers had a mean depth of external fat of 4.8 mm. compared to 6.7 mm. for the control wethers, a difference that was statistically insignificant on the numbers studied (table 6).

In experiment II the depth of external fat over the eye muscle was less on animals that were treated with stilbestrol than controls—the difference being highly significant. This reduction in fat was evident in both ewe and wether lambs with the greater difference being in the ewe lambs. The sex-treatment interaction was not significant.

TABLE 6. THE EFFECTS OF STILBESTROL ON THE CHARACTERISTICS OF THE MEAT SAMPLES

Characteristic	Experiment I		Experiment II	
	Control	Stilbestrol	Control	Stilbestrol
Measurement of external fat (mm.)	6.7	4.8	8.3	5.6**
Weight of external fat (gms.) A.C.W.	19.4	15.8	22.3	17.6**
Weight of internal fat	8.7	7.8	10.3	9.4
Weight of muscle A.C.W. (gms.)	...	...	79.4	80.5
Weight of bone and connective tissue A.C.W. (gms.)	...	...	58.5	62.6**

A.C.W.—Adjusted to carcass weight.
** Highly significant.

Muscle Measurements. Actual muscle measurements were not affected by treatment nor was there a significant difference in muscle size of treated animals and controls when adjusted to carcass weight.

Vertebra Measurements. There were no significant treatment differences in width or height of vertebra either before or after adjusting for carcass weight.

Weight of the Meat Sample. In experiment II meat samples taken from the carcasses of lambs of the stilbestrol group were significantly smaller than the controls. There was a significant correlation between carcass weight and weight of the sample within lots of +.51. Differences in weight of carcass accounted for the treatment differences in weight of sample as originally shown by analysis of variance since there was no significant treatment difference in weight of sample demonstrable after adjustment for carcass weight.

Weight of External Fat. In experiment II analysis of variance of the weight of external fat showed interactions between sex and treatments. The mean weights indicated a decrease in weight of external

fat of both sexes, treated with stilbestrol and that the effect was more pronounced in ewe lambs than in wethers. Further breakdown showed that the effect in wethers only approached significance while a highly significant difference existed between control and stilbestrol treated ewe lambs. Highly significant differences between the stilbestrol animals and the controls still existed after being adjusted to carcass weight (table 6). The difference in weight of external fat was not significant between the treated and control groups of wethers studied in experiment I.

Internal Fat. The weight of the internal fat was not affected significantly by stilbestrol in either experiment I or II (table 6).

Weight of Muscle. The weight of the eye muscle was not affected significantly by treatment in experiment II. Adjustment of muscle

TABLE 7. PER CENT OF WATER IN THE EXTERNAL FAT OF LAMBS
(Experiment II)

Treatment	Wethers	Ewes	Average
Control	10.5	7.7	9.1
Treated	13.8*	11.1**	12.4**

* Significant.
** Highly significant.

weight to carcass weight did not reveal any difference in treatments (table 6). The eye muscles were not weighed separately in experiment I.

Weight of Residue. In experiment I where bone, muscle and connective tissue were not separated the stilbestrol group (average weight 119.0 gms.) had a highly significantly greater amount of these constituents than controls (average weight 107.0 gms.). In experiment II both fat and muscle were separated leaving a residue of bone and connective tissue. The weight of the residue was significantly greater in stilbestrol than in control animals (table 6).

Percent of Water in External Fat. In experiment I external fat was not analyzed for water content but the carcasses appeared more watery in the stilbestrol treated animals than in the controls. In experiment II an analysis was made and the water content of the external fat was higher in stilbestrol treated animals than in controls (table 7). The difference was quite consistent in both wethers and ewes.

A significant negative correlation of —.19 between water content and amount of external fat was found. Analysis of covariance showed that differences in weight of external fat could not explain all the differences in water content of the fat among the treatment means.

A test of significance of deviation from linear regression indicated that the fat-water relationship was non-linear. The reduction due to quadratic regression was highly significant. A further test of significance showed that differences among treatment means still existed when adjustment was made for curvi-linear regression.

Effects of Testosterone

Of all the characteristics studied in experiment I, only the weight of bone, muscle and connective tissue (collectively) of the meat sample from wethers was significantly increased over controls.

In experiment II ewe lambs treated with testosterone ate an average of 3.41 pounds of feed daily which was significantly more than the 3.06 pounds daily for control ewes. The testosterone treated animals reached 100 pounds in an average of 62 days which was significantly sooner than the average of 71 days for the control group.

The testosterone treated animals averaged .48 pounds daily gain compared to .43 for the controls. This difference approached significance.

Sufficient testosterone was given to stimulate greater growth of seminal vesicles as shown by the average index (length×width measurement) of 100.4 for the control wethers compared to 240.3 for the treated. The diameter of the ampullae was also increased highly significantly from 3.2 millimeters for the control to 5.2 for the treated wethers.

The over all effects of testosterone on weight of external fat taken from the meat sample were not significant but a significant interaction existed with the treated wethers (20.2 gms.) having slightly more external fat than the controls (19.2 gms.) and the treated ewes (21.6 gms.) having less than the controls (27.2). The weight of internal fat and muscle were not significantly affected but the weight of the residue (bone and connective tissue) of treated animals (62.5 gms.) was significantly greater than for the controls (59.2). No other significant effects of testosterone were found in the characteristics studied. In general the means for the testosterone group in the various characteristics studied were intermediate between the control and the stilbestrol groups.

Effects of Progesterone

Progesterone had no effect on rate or economy of gain or on carcass characteristics in either experiment but in experiment II it was determined that progesterone depressed follicle diameter in ewes to 4.8 which was significantly less than the 5.8 millimeters for the control ewes.

The Effects of Combinations of Hormones in Experiment I

The average daily gain was significantly greater in wethers receiving a combination of stilbestrol and testosterone than in the controls table 8). Ewes receiving combinations of stilbestrol and progesterone made more rapid daily gains than controls (highly significant). The increased rate of gain appears to be due to the action of stilbestrol since the combination sub-groups do not differ significantly from the stilbestrol treated sub-groups. These observations also fail to indicate

TABLE 8. THE EFFECT OF HORMONE COMBINATION

(Experiment I)

Characteristic	Group	Control	Combination [1, 2]
Daily gain (lbs.)	Wethers [1]	.60	.70*
	Ewes [2]	.48	.70**
Lbs. of feed/100 lbs. gain	Wethers	547	447
	Ewes	660	461*
Dressing percentage	Wethers	45.6	44.0*
	Ewes	46.4	44.6*
Carcass grade	Wethers	4.95	3.80*
	Ewes	5.10	4.00*
Carcass finish	Wethers	4.75	3.75
	Ewes	4.85	4.15

[1] Wethers were treated with combination of stilbestrol and testosterone.
[2] Ewes were treated with combination of stilbestrol and progesterone.
* Significant.
** Highly significant.

any inhibitory action of either testosterone or progesterone on the action of stilbestrol.

Wethers of the combination treatment required 100 pounds less feed per 100 pounds gain (not significant) but treated ewe lambs required significantly less feed per 100 pounds gain, a saving of 199 pounds.

In ewes and in wethers the dressing percentage for the combination treatments was significantly less than for the controls, being 1.6 percent less in the wethers and 1.8 percent less in the ewes (table 8).

The combination sub-groups, both ewes and wethers, had significantly lower carcass grades than controls. The combination of stilbestrol and testosterone treated wethers while not significantly different from the controls in degree of finish, did follow the same trend as the stilbestrol treated wethers and approached significance.

The combined weight of muscle, bone and connective tissue was increased in stilbestrol treated wethers (119.0 gms.) and in the testosterone treated wethers (116.3 gms.) over the controls (107.0 gms.) as noted above, but there was not a significant increase in the sub-group given both hormones (109.7). This indicates some antagonistic effects of the two hormones since the stilbestrol sub-group had a significantly greater amount of muscle, bone and connective tissue than the combination sub-group. There was no other indication of such antagonistic action.

Sex Differences

The differences found between wethers and ewes are based on all lambs in the experiments in which both sexes received the same treatments.

Wether lambs made significantly more rapid daily gains in both experiments. The averages for experiment I were .60 pounds daily for wethers and .54 pounds daily for ewes; for experiment II .56 pounds daily for wethers and .52 for ewes.

The average daily feed consumption for wethers (3.44 pounds) was significantly greater than for ewes (3.31 pounds) in experiment II.

In experiment I wethers required significantly less feed per 100 pounds gain than ewes but in experiment II wethers and ewes were not significantly different in feed efficiency.

In experiment II the live grade of wethers (3.9) was less than for ewes (4.8)—the difference being highly significant.

The carcass grade for wether lambs (4.2) was less than for ewes (4.8). Also carcass finish for wethers (3.7) was less than in ewes (4.2). These sex differences in experiment II were highly significant but in experiment I there was no significant sex difference in either character and the means are not reported.

The dressing percentages were not significantly different between the sexes in either experiments I or II.

In experiment I sex differences in characteristics of the meat sample were not studied. In experiment II the thickness of external fat of wethers (6.3 mm.) was less than in ewes (7.7 mm.) and the water content of this fat was higher in wethers (11.4 percent) than in ewes (9.1 percent)—both differences being highly significant. A highly significant difference was found in width of vertebra with the wethers averaging 20.7 mm. and the ewes 19.8 mm. The average weight of the external fat of the wethers was 18.1 gms. which was less than the 21.8 gms. for the ewes; however, the wethers had more residue

than ewes, being 62.4 gms. and 59.8 gms., respectively. Both differences were highly significant.

Feed Cost, Selling Price and Profits

The total cost of the lambs at the beginning of experiment II in Dec. 1950 was $30.78 per hundredweight. The cost of the feed per hundredweight gain was $16.50 for the control group, $11.08 and $10.84 for the stilbestrol and stilbestrol 2 groups, $15.30 for the testosterone group and $16.51 for the progesterone group. Those groups which had the lower feed cost—St., St. 2, and T.—also had a lower selling price: $28.92, $29.90 and $29.51, respectively, as compared with $30.10 per hundredweight for the control group. The selling price per hundredweight for the progesterone group was $30.35.

Under the conditions of experiment II the cost of feed was cut by approximately one-third by use of stilbestrol; however, because of a slightly lower market grade (not consistently predictable statistically) stilbestrol and testosterone treated lambs brought less per hundredweight when sold on the market. The value of the feed saved, however, was greater than the loss in market value. The return per lamb was consistently more in the St. and St. 2 treated wethers, being approximately $1.50 more per lamb than in the control wethers, but in the ewe lambs returns were inconsistent in that St. ewe lambs returned less while St. 2 ewes returned more than did controls. The testosterone treated group returned less per lamb than did the controls. The progesterone treated group returned $.32 per lamb more than the control group but this would have been insufficient to cover the cost of the hormone used. Also, there was no evidence that progesterone affected the carcass in any way.

General Discussion

Woehling *et al.* (1951) has pointed out the lack of response to stilbestrol in rate of gain and feed efficiency in pigs as compared to increased rate of gain and increased feed efficiency in ruminants. Another point which suggests indirectly that the rumen may play an important role is the lack of response to stilbestrol in young lambs as reported by Jordan and Dinusson, 1950. Digestion studies should be made to determine the rate and completeness of digestion in the rumen and in the other parts of the digestive system.

Stilbestrol treated lambs were more efficient than controls in the utilization of feed when feed intake was the same for both treated and control groups as in experiment I, or when both groups were

fed *ad libitum* as in experiment II. However, feed efficiency is measured in terms of feed required per 100 pounds gain; the nature of this gain should be examined. Part of the additional gain is not in the carcass itself as shown by a lower dressing percentage in the stilbestrol treated animals than in controls at the same final weight.

Since more than half of the animal is composed of parts other than the carcass, these parts should be examined. Part of this gain may be in the various parts of the viscera, in the contents of the digestive tract or in both. Also the weight of the pelt and the fleece may be affected. The exact nature of the gain in these various parts is yet to be determined.

In addition to less carcass from the same final weight, the composition of the carcass from the stilbestrol treated animal has been changed. Stilbestrol lowered the carcass grade and finish of lambs significantly. This lowered grade and finish appears to be due mainly to lack of fat, both in amount and quality. Evidence of this change in the carcass is shown by less weight of external fat in the stilbestrol treated animals than in controls. There was no evidence that the muscle was affected in any way by treatment, but after removing both fat and muscle, a residue, consisting of bone and connective tissue, was left which weighed significantly more in the stilbestrol treated animals than in controls. Since there was no difference between treated and controls in measurements of bones, either metacarpal or vertebra, it appears that this increase is due to an increase in connective tissue and not in bone, unless there is an increase in density of bone. For conclusive evidence actual study of the connective tissue in lamb needs to be made.

The total gain was made more rapidly in the stilbestrol treated animals than in controls. Of this total gain not only in there less external fat but the fat of stilbestrol treated animals contains more water. Thus, the gain made under the influence of stilbestrol is relatively a low energy product.

Although the stilbestrol treated lambs had less external fat than controls at the same final weight, this fat in the treated animals was deposited over a shorter interval of time and it is possible that the difference may be either a time effect or a treatment effect or perhaps both. Likewise, muscle and bone were not significantly different between the two groups at the same final weight and it is presumed that they must have increased at a faster rate in the treated animals than in the controls. In addition to measurements at a constant weight, further tests of fat, muscle and bone growth under the influence of stilbestrol should be done where all lambs are on experiment for the

same length of time. Also a sample of the animals should be slaughtered at the beginning of the experiment to serve as a starting point for determining the relative growth changes that occur during the experimental period.

The effects of testosterone were slight compared to the effects of stilbestrol even when the dosage levels of testosterone were considerably higher than those for stilbestrol. However, the effects observed were in the same direction as those resulting from stilbestrol treatment.

Progesterone, although given in sufficient dosage to depress follicle size, did not show any effects on any of the other characteristics studied.

Summary

Two experiments involving 400 western lambs, 100 ewes and 100 wethers in each experiment, were conducted to determine the effects of stilbestrol, testosterone, and progesterone on growth and fattening and on certain carcass characteristics when each lamb was taken to the same final weight of 100 pounds. The following effects of stilbestrol treatment were indicated when all animals were fed to this same final weight.

1. Greater rate of gain either when controls and treated animals are both self-fed or when feed consumption is limited to the amount that either will consume.
2. Greater feed consumption when self-fed.
3. Greater economy of gain; shorter period of time on feed to reach market weight.
4. Lower live grade but not consistently detectable by the grader.
5. Lower carcass grade.
6. Lower dressing percentage.
7. Smaller amount of external fat.
8. Greater moisture content of external fat.
9. No difference in muscle or internal fat.
10. Greater amount of bone and connective tissue when considered together.
11. Lower feed cost and slightly lower selling price but a greater profit per lamb.

Testosterone tended to inhibit the action of stilbestrol on bone and connective tissue when administered simultaneously with stilbestrol. Neither testosterone nor progesterone tended to modify the other actions of stilbestrol.

The slight effects of testosterone on growth and fattening and certain carcass characteristics were qualitatively of the same character as those of stilbestrol but were much less marked. Progesterone had no detectable effects on these characteristics.

A comparison of the performance of wether and ewe lambs shows for the former:

1. Greater daily feed consumption.
2. Greater daily gain.
3. Greater economy of gain.
4. Lower live grade.
5. Lower carcass grade.
6. Less finish on carcass.
7. Less external fat.
8. Greater water content in external fat.

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HISTOLOGICAL STUDY OF THE DEVELOPMENT OF THE TESTIS OF THE RAM [1]

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QUANTITATIVE studies of the age of appearance of the various cellular elements of the seminiferous tubules of the ram, by breeds, apparently have not been reported. They should be of interest in making recommendations concerning the practical management of young rams.

Phillips and Andrews (1936) castrated a series of 14 Southdown and Shropshire ram lambs at different ages ranging from 21 to 189 days. These authors indicated that up to 42 days of age, only a single row of cells were found lining the basement membrane of the seminiferous tubules. Primary spermatocytes were first found at 63 days; increased numbers of these cells were noted at 84 and 105 days. Secondary spermatocytes were present at 126 days and spermatozoa at 147 days of age. Rams of both breeds apparently were intermingled for the various ages as they were not reported separately.

Breed or line comparisons were not found for the sheep, such as were reported in swine by Green and Winters (1944). The present study was designed to make a quantitative comparison of the various cellular types in the seminiferous tubules of the testes of both the Southdown and Hampshire breeds at different ages.

Experimental Procedure

Thirteen Hampshire ram lambs born in the spring of 1949 were serialized at random such that bilateral castrations could be made at bi-weekly intervals through the ages of two to 26 weeks. Three Southdown ram lambs were available in 1949. Unilateral castrations were made whereby ram *a* was castrated when nine and 11 weeks of age, ram *b* at 14 and 18 weeks, and ram *c* at 20 and 24 weeks. These ages were selected as they were estimated to be critical ages in the development of the testes. In 1950, additional Southdown testes were

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secured by bilateral castration at 9, 11, 20 and 22 weeks of age. All ram lambs within breed and year were paternal half-sibs. The lambs were with their dams, on pasture, until castrations were completed, being confined to a barn only at night. At the time of castration the following data were obtained: (a) age of the ram in weeks; (b) body weight of ram, in pounds; (c) weight, in grams, of each testis plus epididymis, testis alone and epididymis alone; and (d) volume, in ml., of each testis plus epididymis, testis alone and epididymis alone.

The spermatic cord including the vas deferens was removed at its junction with the epididymis and all excessive tissue was removed from the organ prior to measurements.

Small pieces of testicular tissue approximately 3 x 3 x 5 mm. and the middle portion of each epididymis were fixed in Bouin's Picro-Formal fixative (Guyer 1930) within 15 minutes after castration. Dehydration and infiltration of the tissue was based on the butyl alcohol technique of Johansen (1940). The tissue was embedded in Tissue Matt (56° C.), sectioned at five microns, and stained with Heidenhain's iron hematoxylin, long method (Guyer 1930).

For quantitative evaluation, 25 randomly chosen, circular, seminiferous tubules were studied for each ram. The cells of each tubule were classified as to type (spermatogonia, primary and secondary spermatocytes, and spermatids) and counted. Presence of spermatozoa was noted but the numbers were not counted. The diameter of each tubule was measured in microns by the use of a calibrated micrometer eyepiece.

Statistical methods given by Snedecor (1948) were followed. All regression coefficients were calculated on an individual tubule basis, 25 for each ram, rather than the average of all 25 tubules per ram. Linear and quadratic regressions were calculated as indicated. In instances where the quadratic regression resulted in a significant reduction in errors of estimate, that regression was plotted in lieu of the rectilinear. When more than one ram of the Southdown breed was used at any age, each ram was used and calculated as a separate individual.

Results

In the Hampshire lambs (table 1), the number of tubules containing primary spermatocytes were 6, 7, and 20 at 4, 6, and 8 weeks of age, respectively. All 25 tubules per ram contained these cells at the ages of ten weeks and older. All tubules of the nine-week-old Southdown ram contained primary spermatocytes. In both breeds the numbers

TABLE 1. DEVELOPMENT OF THE TESTES OF HAMPSHIRE AND SOUTHDOWN LAMBS AT VARIOUS AGES

Age in Weeks	Average Number of Cells per Tubule [1]				Average Diameter Seminiferous Tubules (Microns)	Body Weight (Pounds)	Average Testes	
	Spermatogonia	Spermatocytes		Spermatids			Weight (grams)	Volume ($mm.^3$)
		Primary	Secondary					
Hampshire								
2	18	0	0	0	33.3	16.3	0.14	1.50
4	21	—	0	0	40.9	23.5	3.26	3.50
6	20	—	0	0	46.4	25.5	3.42	3.50
8	22	1	0	0	42.4	35.0	4.15	3.75
10	32	15	2	0	86.2	42.5	11.07	10.50
12	30	11	1	0	93.2	63.0	28.90	27.00
14	30	15	2	0	95.2	55.0	20.65	23.00
16	31	30	7	0	126.4	66.0	61.92	66.50
18	29	12	—	0	82.3	45.5	20.53	21.50
22	25	12	1	0	83.8	76.0	96.92	87.50
24	30	33	41	39	193.3	95.0	121.68	104.00
26	34	41	53	45	207.7	94.0	104.39	98.50
Southdown								
9*	23	2	0	0	44.9	22.0	3.61	3.50
9**	27	5	0	0	55.0	28.0	11.39	7.00
11*	26	3	0	0	53.0	23.0	5.49	5.00
11**	35	14	0	0	74.8	42.0	31.03	28.00
14*	32	7	0	0	75.8	50.5	14.80	26.00
18*	31	16	1	0	140.8	62.0	57.17	46.00
20*	33	28	9	0	158.4	50.0	51.80	40.00
20**	31	18	—	0	87.9	39.0	26.82	33.00
22*	31	34	35	20	196.1	54.5	67.36	50.00
22**	52	64	66	52	256.6	47.0	38.04	66.00

[1] Where a dash is present the average is less than one.
* Only one testis of one lamb was taken at this age (see text).
** Lambs of the 1950 season (see text).

of these cells continued to increase irregularly throughout the series.

Secondary spermatocytes appeared eight weeks earlier in the Hampshire breed as they were present in 18 tubules of the ten-week-old individual. These cells did not appear in the Southdown breed until the 18 week stage when six tubules were found to contain these cells. Except for a ram or so in each breed, the number of secondary spermatocytes progressively increased with age once they first appeared.

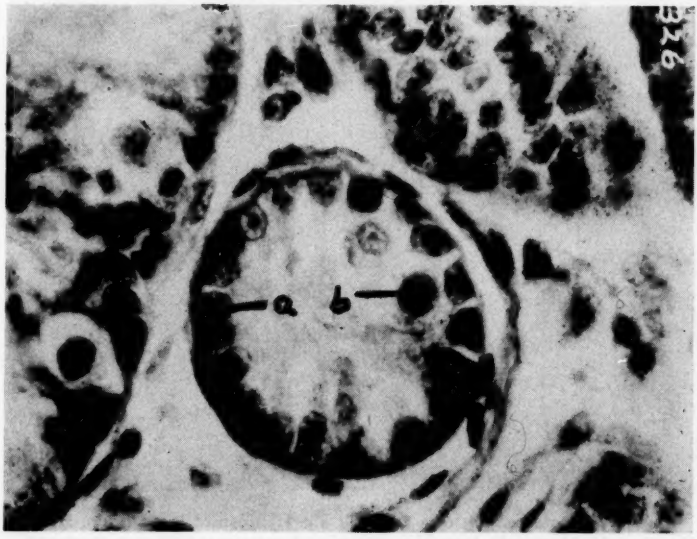

Figure 1. Cross section of a nine week old Southdown ram testis. Bouin's Fixative, Heidenhain's Iron Hematoxylin Stain, 5 microns. 1049 x. a. Spermatogonial cells; b. Primary spermatocytes.

The tubular diameter, testicular weight, testicular volume and body weight of the 18 week old Hampshire lamb were small. This lamb had progressed about as far as the ten-week-old individual. In the 22 week old Hampshire the seminiferous tubular diameter was small, and in relation to age so was the body weight although the weight of the testis appeared to be normal. As far as the Southdowns are concerned, in the 20 week old individual of the 1950 season, the tubular diameter, body weight, and testicular weight are about equal to the 14 week old individual representing this breed.

Spermatids and spermatozoa were first discovered at the ages of 22 weeks in the Southdown and 24 weeks in the Hampshire breed.

Figure 1 illustrates the development of the seminiferous tubules of a nine-week-old Southdown lamb. The spermatogonial cells are arranged in an orderly fashion adjacent to the basement membrane of the tubule. A few primary spermatocytes are evident but the lumen of the tubule

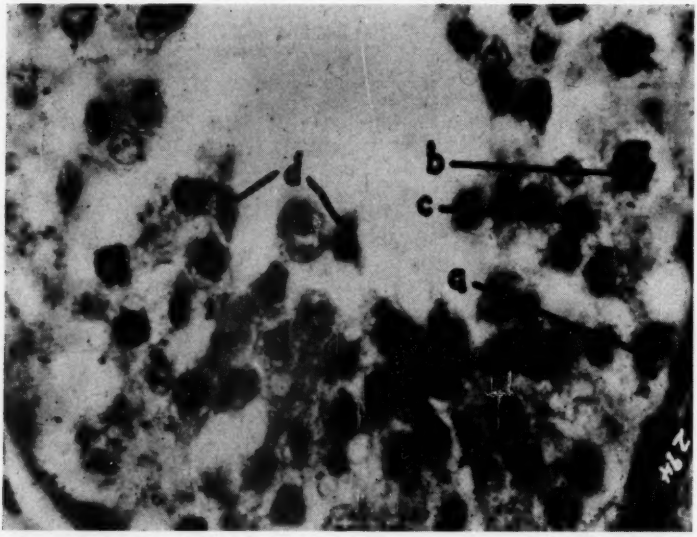

Figure 2. Cross section of a 26 week old Hampshire lamb testis. Bouin's Fixative, Heidenhain's Iron Hematoxylin, 5 microns. 1173 x. a. Spermatogonial cell; b. Primary spermatocyte; c. Secondary spermatocyte; d. Spermatid.

is not completely developed. A cross section of part of a seminiferous tubule of the 26 week old Hampshire ram is shown in figure 2. All cell types are present and the lumen is fully developed. Sperm were found at this age but are not shown in figure 2.

Sections of the epididymis from Hampshire lambs of 4, 6, and 10 weeks of age are shown in figures 3, 4, and 5, respectively. At six weeks, some stratification of the epithelium has been initiated and there was some evidence of secretory activity. Nearly mature development of the lining of the epididymis is found at the ten-week stage. The height of the pseudostratified columnar epithelium of the epididymis

appeared to increase most rapidly in the eight to twelve week age period in the Hampshire breed (26 to 73 microns) and in the eleven to fourteen week age period in the Southdown (15 to 75 microns). This would indicate the possibility of differences between the breeds at these ages either in the amounts of androgen present or in tissue sensitivity and response, or both.

Growth curves of the diameter of seminiferous tubules, cells per

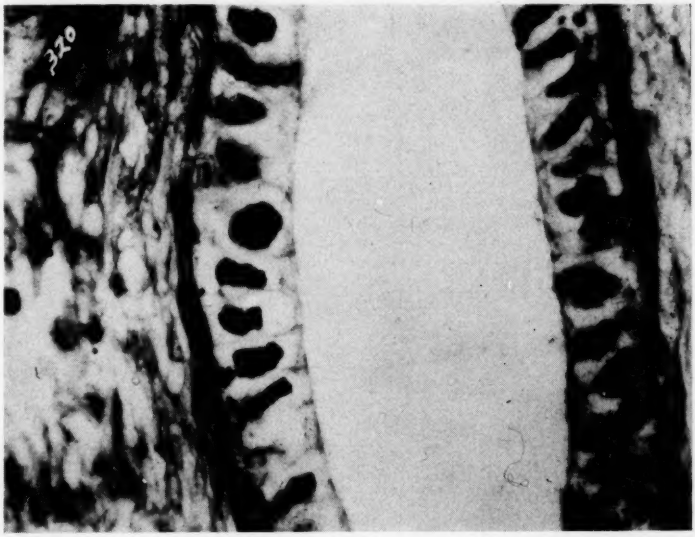

Figure 3. Section of the middle portion of an Epididymis of a four-week old Hampshire lamb. Bouin's Fixative, Heidenhain's Iron Hematoxylin Stain, 5 microns. 1047 x.

tubule, and testicular weight are shown in figures 6 through 9. The graphs given were those regression equations that fit the data best. If the curve is rectilinear the quadratic regression did not cause a statistically significant reduction in errors of estimate from the rectilinear.

Testicular weight clearly demonstrated a quadratic function with age and bodily weight in the Hampshire breed; however, the quadratic function did not demonstrate itself to be significantly more intense than the linear function between testicular weight and age and body weight in the Southdowns (figure 6). The latter result is possibly

attributable to the lack of number of cases in the Southdown to test the hypothesis fully of a better fitting curve with a quadratic function. Further evidence for this latter interpretation is the fact that the parameters are approximately the same for the two quadratic functions determined for the two breeds. A difference was found between breeds in testicular weight in relation to age, but no difference was found in relation to body weight.

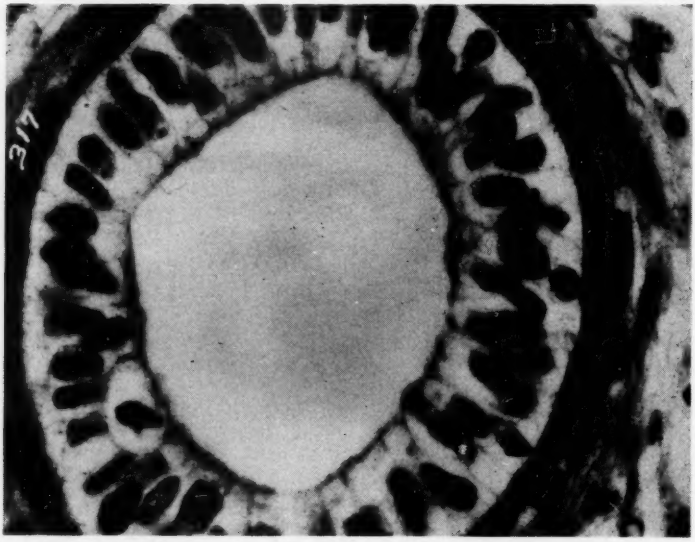

Figure 4. Cross section of the middle portion of an Epididymis of a six-week old Hampshire lamb. Bouin's Fixative, Heidenhain's Iron Hematoxylin Stain, 5 microns, 996 x.

Growth curves of the diameter of seminiferous tubules and the number of spermatogonial cells as associated with age, testicular weight, and body weight are shown for both breeds in figures 7 and 8. It may be noted that the growth of the tubules presented different patterns for the two breeds. These differences in diameter of seminiferous tubules were expressed in relation to age, body weight, and testicular weight. A breed difference was found in spermatogonial cells in relation to age.

Primary spermatocytes demonstrated a rectilinear function with average testicular weight in Hampshires but a curvilinear (quadratic)

with body weight or age. The function was quadratic with all three variables in the Southdown breed (figure 9). A breed difference was expressed in relation to all three variables age, body weight and testicular weight.

By the use of the analysis of variance, no differences were found in weight between the left and right testes or left and right epididymis, or in the volume of left and right testes.

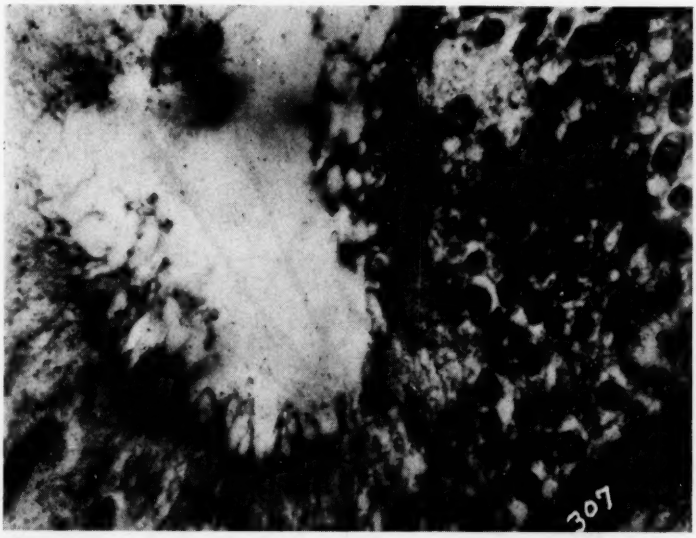

Figure 5. Cross section of the middle portion of an Epididymis of a ten-week old Hampshire lamb. Bouin's Fixative, Heidenhain's Iron Hematoxylin Stain, 5 microns. 1038 x.

Discussion

The age of appearance of various cellular types in the seminiferous tubules in the Southdown breed agreed with the report of Phillips and Andrews (1936), when primary and secondary spermatocytes were found to be present at nine and 18 weeks, respectively. One slight and probably insignificant difference was noted, however, in that the spermatids and spermatozoa were found to appear at 22 weeks in this report and at 21 weeks in that of Phillips and Andrews.

The Hampshire breed appeared to develop a little more rapidly than the Southdown breed. Whether or not the primary spermatocytes

would be present before nine weeks in the Southdown is still open to question, because of the fact that the youngest Southdown secured was the nine week old individual and in that individual an average of 4 primary spermatocytes per tubule was found.

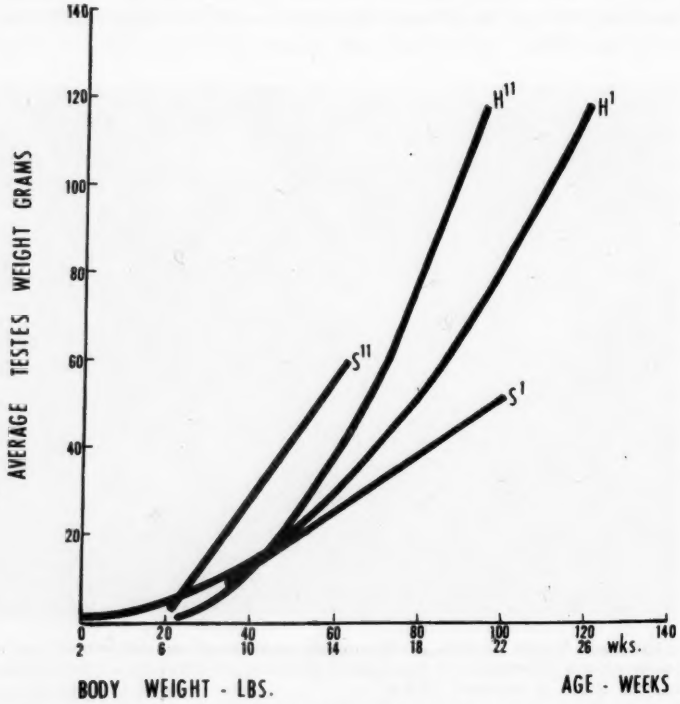

Figure 6. Relationship of Testicular weight to age (H^1) and body weight (H^{11}) for the Hampshire, and (S^1) and (S^{11}) respectively for the Southdown breed.

The main difference between the two breeds seems to be the time at which the secondary spermatocytes appeared, in that the Hampshire breed had these cells eight weeks earlier than the Southdown.

Although there were two weeks difference between the two breeds in the age of appearance of spermatids and spermatozoa this difference is probably of no significance.

The difference in growth patterns as exhibited in figures 6 through 9 along with the correlations in table 2 indicate further differences

between the breeds. These indications are of interest but before it can be definitely proven that there is a real difference between the breeds more studies would have to be conductd gathering testes from a greater number of individuals of each breed at the different ages.

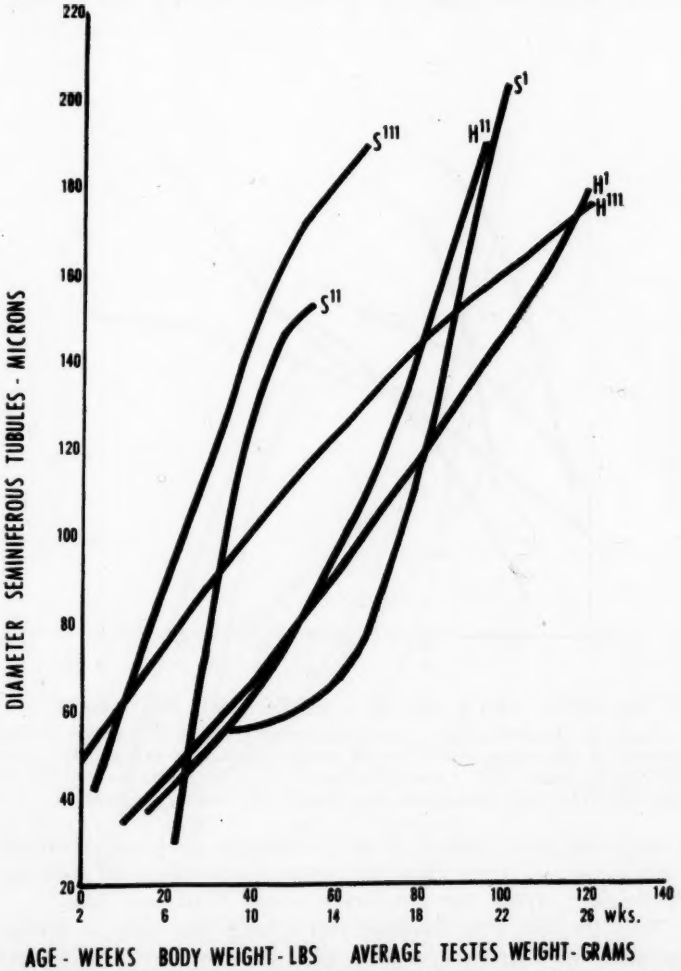

Figure 7. Quadratic regressions illustrating the rate of increase in the diameter of seminiferous tubules in relation to age (H^{1}) and (S^{1}); body weight (H^{11}) and (S^{11}); and average testicular weight, (H^{111}) and (S^{111}) for the Hampshire and Southdown breeds respectively.

There was a difference between the two breeds in the time that the pseudostratified columnar epithelium of the epididymis started to increase. This increase was observed about three weeks earlier in the Hampshire breed.

From observations unilateral castration of the first season South-

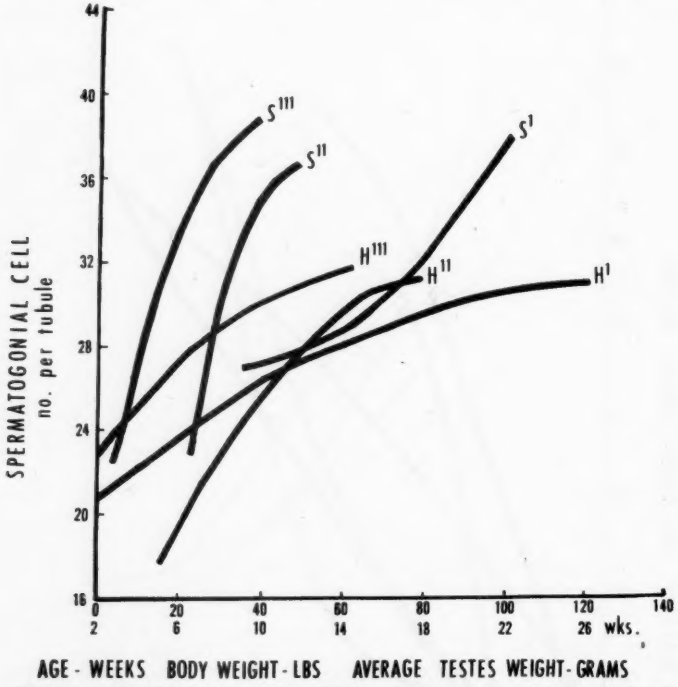

Figure 8. Quadratic regressions illustrating the rate of increase in the number of spermatogonial cells per tubule in relation to age (H^{I}) and (S^{I}); body weight, (H^{II}) and (S^{II}) and average testicular weight (H^{III}) and (S^{III}) for the Hampshire and Southdown breeds respectively.

downs, with later removal of the second testis, did not apparently affect the second testis. There was general agreement in the testicular development of the first and second season Southdown rams.

From the data it is concluded that a lamb may begin to develop secondary sex characters at about eight to twelve weeks of age and that he may be fertile when he reaches the age of 22 weeks. He should be removed from the ewe flock before this age to prevent accidental or unwanted matings.

Summary

Individuals from a group of 12 Hampshire ram lambs were serialized and castrated at bi-weekly intervals from two to 26 weeks of age. Seven Southdown rams were used to secure testes for ages of nine to

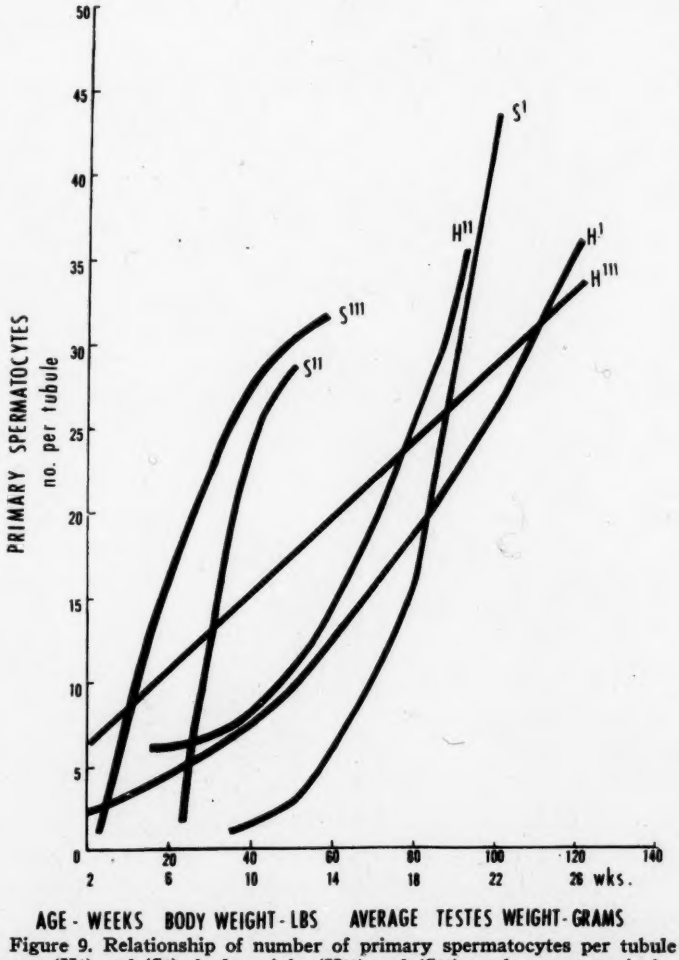

Figure 9. Relationship of number of primary spermatocytes per tubule to age (H^{1}) and (S^{1}); body weight (H^{11}) and (S^{11}); and average testicular weight, (H^{111}) and (S^{111}) for the Hampshire and Southdown breeds respectively.

TABLE 2. ZERO ORDER (r) AND MULTIPLE (QUADRATIC) CORRELATIONS (R) BETWEEN VARIOUS MEASURES OF THE TESTES OF HAMPSHIRE AND SOUTHDOWN RAM LAMBS *

	Southdown		Hampshires	
	r	R	r	R
Testicular weight with age	0.799	0.799	0.903	0.940 [ab]
Seminiferous tubule diameter with age	0.731	0.864 [ab]	0.841	0.851 [a]
Spermatogonial cells per tubule with age	0.504	0.930 [ab]	0.654	0.713 [a]
Primary spermatocytes per tubule with age	0.759	0.825 [ab]	0.683	0.766 [a]
Testicular weight with bodily weight	0.853	0.854	0.938	0.968 [a]
Seminiferous tubule diameter with bodily weight	0.637	0.684 [a]	0.894	0.914 [ab]
Spermatogonial cells per tubule with bodily weight	0.384	0.563 [a]	0.678	0.754 [a]
Primary spermatocytes per tubule with bodily weight	0.469	0.567 [a]	0.729	0.768 [ab]
Seminiferous tubule diameter with testicular weight	0.737	0.746 [a]	0.837	0.842 [ab]
Spermatogonial cells per tubule with testicular weight	0.310	0.770 [a]	0.487	0.677 [a]
Primary spermatocytes per tubule with testicular weight	0.570	0.616 [a]	0.716	0.718 [b]

* All correlations are statistically highly significant ($P=<0.01$).
[a] The multiple (quadratic) is significantly (statistically) higher than the zero order.
[b] Significant difference between breeds.

22 weeks. At the time of castration the body weight and age of the ram were recorded as well as the weight and volume of each testis and each epididymis. The center portion of each testis and epididymis were fixed in Bouin's fixative, sectioned at five microns and stained with Heidenhain's Iron Hematoxylin. The development of the testis was evaluated by its weight and volume, diameter of its seminiferous tubules, and the number of each cell type (spermatogonia, primary and secondary spermatocytes, spermatids and spermatozoa) per tubule. The diameters of 25 randomly chosen seminiferous tubules were measured and the cells were then counted.

Qualitatively, primary spermatocytes were present in the Hampshire ram lamb at four weeks of age while these cells were found for the first time in the Southdown lamb at nine weeks of age. A few secondary spermatocytes were found in the ten week old Hampshire ram but not until 18 weeks in the Southdown. Spermatids were seen for the first time in the 22 week old Southdown and at 24 weeks in the Hampshire. It was concluded that rams were fertile when they were five and one-half to six months of age.

Quantitatively, the volume of the testis increased directly with testicular weight. The diameter of seminiferous tubules increased in a curvilinear (quadratic) manner when compared with age, bodily weight or testicular weight. Some breed differences were found in the rate of increase in cellular types in relationship to age, body weight, and testicular weight.

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THE DIGESTIBILITY OF COARSELY GROUND AND FINELY GROUND ALFALFA FOR DAIRY HEIFERS [1]

ERIC W. SWANSON [2] and H. A. HERMAN

University of Missouri

IN the course of digestion trials with Korean lespedeza hay, alfalfa hay and mixtures of these with Korean lespedeza seed it was noted that heifers fed ground alfalfa mixed with other feeds ruminated very infrequently. The question arose as to whether or not this finely ground hay was being digested differently than long-cut hay because of the difference in rumination. There have been several previous experiments in which long-hay has been compared with chopped hay or ground hay. Many of these were simple feeding trials to determine the economy or desirability of grinding hay for milk or meat production. However, a few previous observations of the comparative digestibility of ground or chopped hay and long-hay have been made. Forbes (1925) found that the dry matter of ground alfalfa hay was 2.2 percent less digestible than that of coarsely cut hay. Bechdel (1928) found that grinding hay caused a slight increase in digestibility of the total ration when fed with grain, but crude fiber digestibility was decreased. He also noted that rumination was decreased 27 percent on the ground hay. Morrow and coworkers (1929) found no significant difference in digestibility between ground and unground hay. Olson (1930) found that grinding of alfalfa, corn fodder, wild hay, or sweet clover fed alone or with silage and grain caused no increase in digestibility and in some trials a definite decrease in digestibility was recorded. Mead and Goss (1935) reported that fine grinding lowered the digestibility of crude fiber. Kick and coworkers (1937) noted a decrease in time spent chewing and ruminating when hay was finely chopped but did not determine digestion coefficients. Cole and Mead (1943) have noted a lack of rumination on rations low in coarse material, such as ground alfalfa, but did not compare digestion efficiencies.

The reports in the literature are not in agreement regarding the effect of grinding hay upon its digestibility. In all cases, however, only two degrees of coarseness were compared and other feeds often were present in the ration besides the hay. The effect of rumination

[1] Contribution from the Department of Dairy Husbandry, Missouri Agricultural Experiment Station, Journal Series No. 1299.

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upon digestibility has not been stressed. It seemed that if there were a correlation between fineness of grinding hay and digestibility of the hay, three degrees of fineness in grinding would indicate it more clearly than only two. Also, if rumination were depressed proportionally to the fineness of grinding hay, this fact might have some bearing on any observed differences in feed utilization. Accordingly, an experiment was conducted to test these ideas.

Experimental Procedure

A supply of green but stemmy alfalfa hay which was bought at the Kansas City market and reported to be Nebraska grown was set aside for the experiment. It was chopped or ground into three degrees of fineness. The coarse chopped hay was prepared with an ensilage cutter operated with the apron traveling at top speed. This resulted in hay chopped 1.5 to 3.0 inches in length with an average density of 6.25 pounds per bushel. The medium ground hay was prepared in a hammer mill with a one-inch screen. The product was moderately fine in appearance with few stems exceeding one-half inch in length. The average density of this hay was 10.23 pounds per bushel. The finely ground hay was prepared in a hammer mill with a five-sixteenths-inch screen. The resulting hay was a finely ground meal with no stemmy appearance whatsoever. It averaged 13.31 pounds per bushel.

Digestion trials were conducted with four Holstein heifers about 16 months of age which had been accustomed to the collection apparatus in previous digestion trials. They were fed the hays in amounts to insure nearly complete consumption. No difficulty was found in getting slightly over two pounds of hay per 100 pounds body weight consumed by all of the heifers. Preliminary periods were of ten days duration followed by ten-day collection periods. Standard analyses were made from composite samples of the feces which were kept acidified and refrigerated following daily collections. A portion of the coarse chopped hay was refused by three of the animals. The refuse was analyzed and correction was made of the intake feedstuff accordingly.

Results and Discussion

The composition of the hay fed in all trials on a dry basis was 14.81 percent crude protein, 35.82 percent crude fiber, 1.61 percent ether extract, 38.70 percent nitrogen-free extract, and 9.06 percent mineral matter. Rumination was observed to be normal on the coarse chopped ration, very infrequent on the medium ground, and it was

not observed at all on the fine ground hay. These observations were made by persons working near the heifers throughout the daytime. Precise data as to the number of champs per bolus or the time spent in rumination were not collected. However, it was certain that the three rations showed the desired differences in rumination; that is, roughly proportional to the coarseness of the forage.

TABLE 1. DIGESTIBILITY OF FINE, MEDIUM, AND COARSE CHOPPED ALFALFA HAY FOR DAIRY CATTLE [1]

Type of Hay and Animal No.	Coefficients of Apparent Digestibility						T.D.N. Dry Basis
	Crude Protein	Crude Fiber	Ether Extract	N-Free Extract	Organic Matter	Dry Matter	
	(Percent)						
Finely ground							
No. 70	72.65	48.78	26.93	69.15	60.95	59.99	55.97
No. 71	72.19	47.14	20.96	67.48	59.41	58.69	54.45
No. 72	72.74	45.11	21.25	66.27	58.19	56.40	53.35
No. 74	72.59	37.85	15.28	65.34	54.81	54.05	50.15
Mean	72.54	44.72	21.06	67.06	58.34	57.28	53.48
Std. error	.12	2.41	2.52	.87	1.31	1.31	1.23
Medium ground							
No. 70	71.34	46.49	16.51	63.48	57.24	56.12	52.38
No. 71	69.01	45.54	13.38	64.65	56.93	56.20	52.04
No. 72	67.57	45.16	8.25	65.64	56.88	56.12	51.88
No. 74	69.72	44.96	13.90	64.10	56.60	55.90	51.74
Mean	69.41	45.54	13.01	64.47	56.91	56.09	52.01
Std. error	.78	.34	1.73	.46	.13	.02	.14
Coarsely chopped							
No. 70	69.65	43.26	15.92	65.44	56.59	55.89	51.79
No. 71	70.73	45.58	7.38	66.34	57.91	57.15	52.82
No. 72	69.92	45.24	36.92	66.63	58.22	56.27	53.68
No. 74	73.15	49.00	25.23	66.41	60.00	58.58	55.09
Mean	70.86	45.77	21.36	66.21	58.18	56.97	53.35
Std. error	.80	1.19	6.34	.26	.70	.60	.70

[1] The ground hays were fed in the sequence listed.

The results of the digestion trials are shown in table 1. The digestibility of the hay did not follow a pattern proportional to the fineness of grinding the hay. The significance of differences in digestibility among rations was determined by analysis of variance. The differences among rations in coefficient of apparent digestibility of total organic matter and total dry matter and in total digestible nutrients were not significant. The mean total digestible nutrients provided by the hays on a dry basis were 53.48 ± 1.23 percent for the finely ground, 52.01 ± 0.14 percent for the medium ground, and 53.35 ± 0.70 percent for the coarsely ground hay.

The average crude fiber digestion coefficients were the only ones which varied according to the fineness of grinding. The mean values

were 44.72±2.41 percent for the finely ground hay, 45.54±0.34 percent for the medium ground hay, and 45.77±1.19 percent for the coarsely ground hay. The mean differences, although suggestive of a slightly lower digestibility of crude fiber with increasing fineness of grinding, were not statistically significant.

The coefficients of digestibility of the ether extract varied widely among the rations and among animals on the same ration. The mean values were 21.06±2.52 percent for the finely ground alfalfa, 13.01±1.73 percent for the medium ground, and 21.36±6.34 percent for the coarsely ground hay. The mean differences between rations were not significant statistically.

The variations among the three rations in digestibility of nitrogen-free extract were barely significant, but they did not follow the pattern of fineness of grinding. The finely ground hay was highest with a mean digestion coefficient of 67.06±0.87 percent; the medium ground hay had the lowest with a mean of 64.47±0.46 percent, with the coarsely chopped hay roughly intermediate at 66.21±0.26 percent. The medium chopped hay was significantly lower than either the coarse or fine hay, but the difference between the latter two could easily have occurred as a result of chance.

The digestion coefficients for crude protein also did not follow the pattern of the fineness of grinding. The mean values were 72.54±0.12 percent for the finely ground, 69.41±0.78 percent for the medium ground, and 70.86±0.80 percent for the coarsely ground hay. The difference between the digestion coefficients for crude protein of the fine and medium ground hay was significant statistically ($P<.01$). Other inter-ration differences were not significant.

It is apparent that the fineness of grinding and/or the degree of mastication and rumination had no important effect upon the total digestibility of this alfalfa hay. Evidently, grinding to such fineness that rumination is not stimulated also has divided the feed finely enough to permit digestion to proceed equally as well as when the animal does the grinding with its teeth in the rumination process. Digestion must be as complete with ground hay only soaked and fermented in the rumen following swallowing as with coarse hay which has been soaked for a variable period of time in the rumen, regurgitated, chewed and returned to the rumen for further action. This is a logical assumption in view of the lack of enzymatic activity in bovine saliva. These observations thus confirm those of previous investigators who found no difference or very slight differences in digestibility between long hay and chopped or ground hay, and also show that even with

very finely ground hay no significant difference in digestibility can be expected.

Summary and Conclusions

The rumination and digestibility of alfalfa hay by dairy cattle (Holstein heifers) has been compared when it was chopped, ground, and finely ground. The average coefficients of digestibility of the dry matter with four Holstein heifers were 57.28±1.31, 56.09±.02, and 56.97±.60 percent respectively for chopped, ground, and finely ground hay. Consistent differences in digestibility of the constituents of the hay were not correlated with the degree of fineness. Normal rumination occurred on the chopped hay, but rumination ceased during the finely ground feeding trial. Since no significant differences in digestibility of the alfalfa hay could be attributed to the fineness of grinding, it was concluded that rumination is not essential for normal digestibility of ground alfalfa hay.

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OBSERVATIONS ON THE ELECTROCARDIOGRAMS OF CATTLE FED THYROPROTEIN [1]

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U. S. Department of Agriculture [2]

In recent years considerable experimental work has been done on the feeding of thyroprotein to dairy cows in an effort to define the conditions under which thyroidally active materials can be used to increase milk production. It has been demonstrated that, when a hyperthyroid state is induced in milking cows by feeding thyroprotein, it is usually accompanied by an increase in milk production. The effects of continued hyperthyroidism for a considerable portion of any one lactation or for several succeeding lactations on the longevity and general health of cattle fed thyroprotein are of interest if thyroprotein is to be introduced in dairy cattle feeding practices. If prolonged hyperthyroidism has deleterious effects in cattle it might be expected that some change in cardio-vascular function could be detected.

Several investigators have made electrocardiographic observations on dairy cattle in which some degree of hyperthyroidism was induced. (Ralston *et al.* (1940), Dyrendahl (1950), Thorbeck *et al.* (1948).) Although Blaxter (1945, 1946) did not obtain electrocardiograms, he observed arrhythmias, abnormal heart sounds and extrasystoles by auscultation in cows fed iodinated casein as well as in apparently normal cows. Blaxter (1948) observed similar abnormalities in sheep which had been fed excessive doses of iodinated protein and Mullick, Alfredson and Reineke (1948) noted changes in the amplitude of the T wave in sheep which was associated with altered thyroid status.

The results which have been obtained in the present study do not differ materially from those obtained by Blaxter (1945, 1946) and Dyrendahl (1950) on cattle. They have, however, been obtained on cattle which have been maintained in a hyperthyroid condition during several successive lactations in contrast to the much shorter period of observation of previous workers and are further evidence that prolonged hyperthyroidism does not severely damage the heart of cattle to any great extent.

[1] The thyroprotein used in this work was Protamone, a product of Cerophyll Laboratories, Inc., Kansas City, Missouri, and was supplied through the courtesy of Dr. W. R. Graham, Jr.

[2] Bureau of Dairy Industry, A.R.A., Washington, D. C.

Procedure

The cattle which were observed in this study were mature females. During the lactation period thyroprotein feeding was started at the 50th day of lactation and continued until 90 days before the next expected calving, a period of 220 or more days. This procedure, beginning with the first lactation, was followed for each lactation for as long as the cow remained in the herd. The number of lactations which were observed ranged from 1 to 6, the average being 3.2. A total of 19 cows which had been fed thyroprotein were studied. Thyroprotein was usually fed at the rate of 1.0 g. per 100 lbs. of body weight. In some instances it was fed at 0.75 or 1.5 g. per 100 lbs. of body weight for short periods. This level of thyroprotein feeding produced accelerated heart and respiratory rates, evidence of a hyperthyroid condition. An additional 7 cows were maintained as controls during this period. They were fed and handled in the same manner as the experimental animals but were not fed thyroprotein.

One or more electrocardiograms were obtained on these animals during each lactation when thyroprotein was being fed. Additional electrocardiograms were obtained during the 90-day interval between lactations when no thyroprotein was being fed. In the case of the control cows, records were made in both lactating and non-lactating periods. The electrocardiograms were made with the Sanborn Portocardiograph [3] using the procedures described by Alfredson and Sykes (1942). Since Lead II is usually the most favorable lead in the electrocardiograms of cattle all measurements of interval length and T wave amplitude were made in this lead. Unfortunately, this equipment was not available when the thyroprotein feeding experiment was started and control electrocardiograms were not obtained on a majority of the cows before thyroprotein was fed. As a result of this, the data from the 7 control cows and that of Alfredson and Sykes (1942), which involved observations on 97 normal dairy cattle, have been used as control data for comparative purposes.

Results and Discussion

Abnormal Types of Electrocardiograms

Atypical electrocardiograms were observed in only 6 of the 19 cows fed thyroprotein. Illustrations of these are shown in figure 1. The electrocardiograms of three of these cows were not distinctly abnormal

[3] This instrument was made available to us for our earlier work through the courtesy of Dr. J. M. Hundley of the National Institutes of Health, Bethesda, Md.

(figure 1d, e). They differed from types seen in normal cows by Alfredson and Sykes (1942) in only minor respects. The QRS interval was usually prolonged or in the upper normal range for cows; extrasystoles were observed in one cow; Q and S waves were sometimes exaggerated and in one case a change in type occurred during the period of observation. They were therefore classed as being abnormal on relatively minor differences. The electrocardiograms of the other three cows of this group were definitely atypical (figure 1a, b, c).

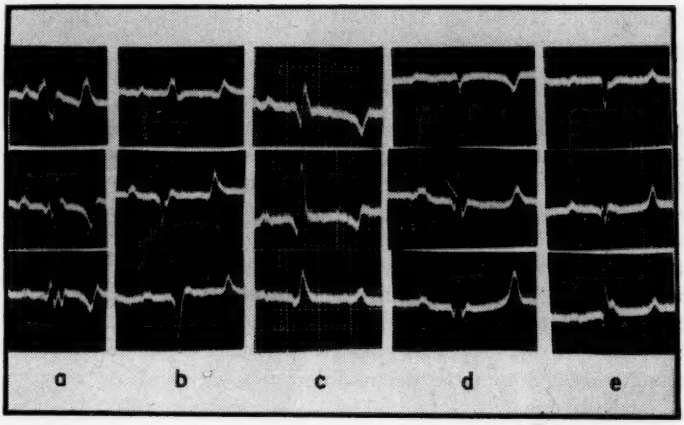

Figure 1. Atypical electrocardiograms of cattle which were fed thyroprotein.

Unusual types of QRS complexes were present, Q was often exaggerated, the QRS interval was longer or in the upper normal range and extrasystoles were observed in two of these cows.

Extrasystoles were not observed with any degree of consistency. They were never seen in more than one record of any cow in spite of the fact that as many as 9 separate records were obtained on some of these cows and in one instance they were absent from Lead II when they were present in Leads I and III. In one cow, whose electrocardiogram was otherwise normal, an extrasystole was seen on one occasion in Lead III only. Tracings for the three leads were not obtained simultaneously. Extrasystoles were seen in 4 of the 19 cows fed thyroprotein. They were never seen in the 7 control cows which were observed over the same interval of time and whose electrocardiograms were normal nor were they observed in the more extensive study

of normal cattle made by Alfredson and Sykes (1942). No extrasystoles were seen during those periods when the cows were not being fed thyroprotein.

These observations on the incidence of extrasystoles in cattle appear to differ from those reported by Blaxter (1945, 1946). Extrasystoles appeared to be more frequently and consistently observed in Blaxter's work and in one instance extrasystoles were detected in an apparently normal cow. It is possible that the apparent difference in the observations of Blaxter and those of the present work is due to the difference in method of observation. Electrocardiograms were not obtained by Blaxter and detection of extrasystoles was by auscultation. During the course of the present work, heart rates were regularly determined by auscultation. With this method, what appeared to be missed beats followed by a beat with exaggerated heart sounds and a divided first sound were observed frequently in thyroprotein-fed cows and in some instances in control cows. This type of arrhythmia appeared at frequent intervals but was not particularly regular nor associated with respiration. It was usually absent during those periods when the cattle were not being fed thyroprotein. By auscultation, this type of arrhythmia was very suggestive of the occurrence of extrasystoles. However, extrasystoles were never detected on the electrocardiograms during these periods of arrhythmia even though simultaneous observations by auscultation and with the electrocardiograph were made in an effort to establish this fact.

The lack of direct control electrocardiograms on the experimental cows and the infrequency of occurrence of atypical electrocardiograms, leaves some doubt as to whether these were effects of feeding thyroprotein. However, since these types had not previously been seen in normal cattle and since extrasystoles have not been previously demonstrated electrocardiographically in apparently normal cattle, it is possible that a few cattle will react in this manner to prolonged thyroprotein feeding.

Variations in the Deflections in Successive Electrocardiograms

Variations in the form of QRS and T occurred in successive tracings of 7 of the experimental animals and in 2 control cows. Types of change which were seen are shown in figure 2.

Variations in amplitude of T II occurred frequently. A variation of 0.20 to 0.40 millivolts occurred in the records of 9 cows, a 0.60 millivolt variation was seen in another and variations of 0.15 millivolts or less occurred in the records of 9 other cattle.

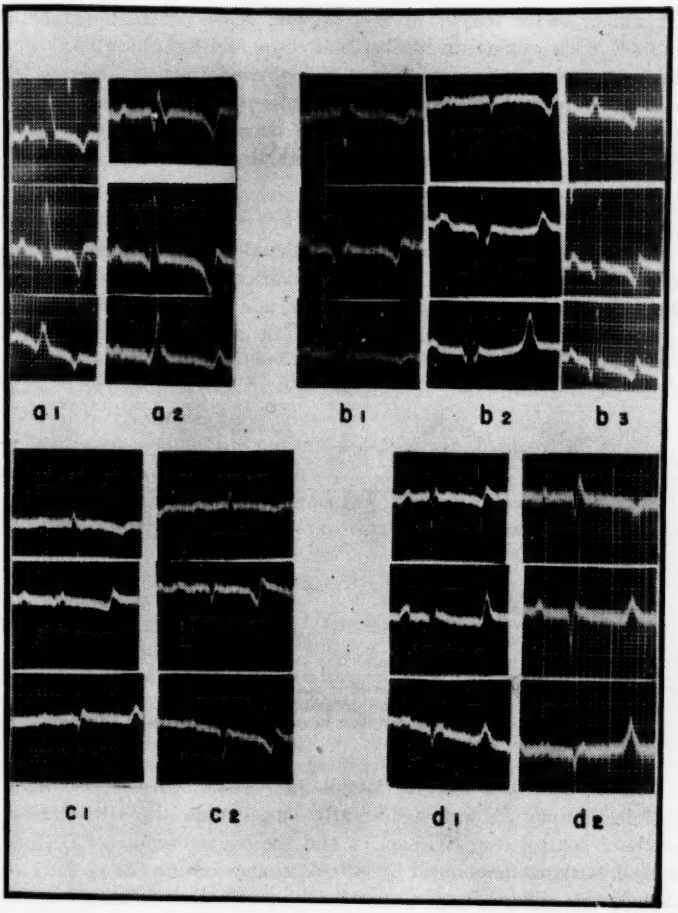

Figure 2. Variations of QRS and T in serial electrocardiograms.

Variations of this type and magnitude were also seen in the control cows and in the larger population of normal cattle studied by Alfredson and Sykes (1942). In the present study, the variations seen could not be related to the thyroid status of the animals at the time the records were obtained and since similar variations have been observed in apparently normal cattle it appears evident that these variations were

not related to the feeding of thyroprotein. These observations are in contrast to the findings of Mullick, Alfredson and Reineke (1948) who observed a decrease in amplitude of T in thyroidectomized sheep which returned to normal or above when thyroprotein was fed, and those of Ralston *et al.* (1940) who observed a decrease in amplitude of T in one goat which had been injected with thyroxine.

Changes in Length of Intervals of Electrocardiograms

The only significant variation from normal in interval length which was observed was in the QRS and Q-T intervals. Average values for the several intervals are shown in table 1.

TABLE 1. EFFECT OF FEEDING THYROPROTEIN ON INTERVAL LENGTH OF THE BOVINE ELECTROCARDIOGRAMS

Group	Number of Cattle	Intervals [b]			Heart Rate (beats/min.)
		P-R	QRS	Q-T	
		(sec.)	(sec.)	(sec.)	
1. Controls	7	.197±.021	.086±.007	.412±.029	73.8±8
2. All cows fed thyroprotein	19	.197±.021	.107±.028**	.419±.051	74.3±11
3. Thyroprotein cows with abnormal electrocardiograms	6	.203±.018	.132±.025**	.451±.042**	72.8±11
4. Thyroprotein cows with normal electrocardiograms	13	.192±.023	.087±.019	.390±.036	75.1±13
5. Alfredson and Sykes (8) data	97	.19 ±.019	.09 ±.018	.39 ±.066	67.8 [a]

[a] Average rate for 72 cows over 18 months of age.
[b] These are average values with standard deviation.
** Differences between these values and those shown in groups 1, 4 and 5 significant at the 1% level by the "T" test.

The average QRS interval for all the cows which were fed thyroprotein (Group 2) was significantly longer than the QRS interval of the 7 control cows (Group 1) and the average value of QRS for normal cattle as determined by Alfredson and Sykes (Group 5). Even though this difference was statistically significant values of similar length frequently occurred in normal cattle.

A larger and more consistent difference in both QRS and Q-T occurred in the 6 cows whose electrocardiograms were considered to be atypical (Group 3). When the data from these 6 cows were excluded from group 2, the average values of QRS and Q-T for the remaining 13 cows (Group 4) were not significantly different from those of normal cattle. This comparison indicates that the QRS and Q-T intervals of a majority of the cows were unaffected by feeding thyroprotein.

While the same limitations regarding lack of direct controls exist here as was noted previously it is possible that the prolonged QRS and Q-T intervals of the 6 cows with atypical electrocardiograms may have been a result of feeding thyroprotein.

Summary and Conclusions

Atypical electrocardiograms were observed in 6 of 19 cows which were fed thyroprotein in successive lactations.

Extrasystoles were detected in only 4 cows. These occurred infrequently and inconstantly. They were not seen during periods when thyroprotein was not fed nor in the electrocardiograms of normal cattle.

Variations in the form of QRS and in the type and amplitude of T occurred rather frequently. These also occurred in control cows and in the experimental cows it was not possible to correlate these variations with thyroid status.

The length of the QRS and Q-T interval was increased in only 6 of 19 cows fed thyroprotein.

No electrocardiographic evidence was obtained that serious damage to the heart was produced by feeding thyroprotein for prolonged periods.

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A PROFILOMETER FOR STUDYING HEAD FORM OF THE BOVINE[1,2]

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DURING the investigations at our laboratory concerning the physical manifestations of the dwarf gene in cattle, it became imperative to develop more refined methods and techniques to aid in identifying the different genotypes associated with the dwarf locus. The limited data of Johnson *et al.* (1950) indicated that this anomaly is conditioned by an autosomal recessive gene, and this is confirmed by more extensive data collected by Gregory *et al.* (unpublished).

Observations upon the dwarfs indicated that their heads were consistently different from those of normal animals in both proportion and conformation. Therefore it was suspected that an instrument which would record the head profile with precision might be of value, not only in studying the dwarfs, but in separating homozygous normal animals from the heterozygous normal (carriers of the dwarf gene), on the assumption that the two genotypes possess slight but consistent differences with regard to head shape.

The instrument described in this report was first visualized by the senior author. The problem of construction was placed in the hands of the junior author who was responsible for most of the engineering details. It required several months to develop a model that was successful in meeting all the demands in the field, and improvements are continually being made. The instrument is referred to as a profilometer and is shown in figure 1.

Most of the material is made from a hard aluminum alloy known as dural, but standard screws, springs, brass tubing, etc., are also used. The frame is composed of parallel bars joined at each end and constructed in such a way as to provide a track which carries a sliding block in which is mounted a contour follower. A ball point recording pen is attached at a right angle to the contour follower. The head contour is recorded on graph paper held on the back board by clips. Adjustable springs are used to produce the correct amount of pressure on both the contour follower and recording pen. Thus with this

[1] This work was supported by the Kellogg Fund for the application of Genetics to farm mammals.

[2] This study was in cooperation with the Bureau of Animal Industry, USDA and the State Experiment Stations under Western Regional Project W-1 on Beef Cattle Breeding Research.

[3] Davis, California.

mechanism, when the instrument is held firmly to an uneven or undulating surface and the block carrying the contour follower is moved along the track, the profile or contour of the body surface is recorded.

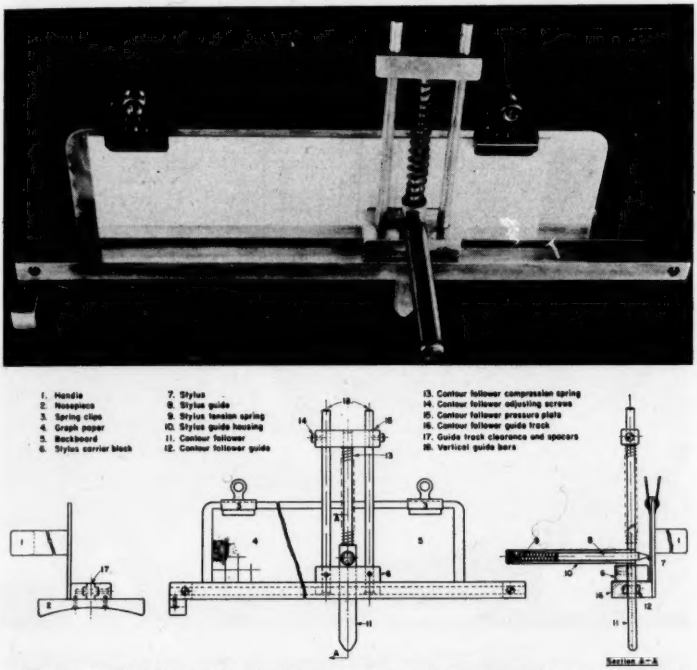

Figure 1. Details of the Profilometer. Top: A photograph of a side view. Bottom: (Left): Diagram of the left end. (Middle): Diagram of a side view. (Right): Section A-A showing the details of the essential mechanism of the block carrying the contour follower, and recording stylus in relation to the graph paper held on the back board or plate.

The instrument is specifically designed to reproduce the contour of an undulating surface, but the model shown is especially adapted to record the profile of the bovine head. The length of the profilometer can be made to accommodate the length of the heads to be measured. One with an over-all length of 35 cm. is satisfactory for young animals; while one with an over-all length of 56 cm. has been used successfully with mature animals. In obtaining a head contour it is necessary to

restrain the animal in some way, preferably by placing it in a chute or a squeeze. A median head profile is obtained by placing the nosepiece on the firm tissue immediately above the nostrils and the opposite end of the instrument on the frontal eminence at the poll (figure 2). Both ends should be held firmly by someone other than the operator. The operator of the instrument then moves the block carrying the

Figure 2. Photograph of the Profilometer at the correct position for obtaining the median head profile.

contour follower and recording stylus along the track and the profile is reproduced on the graph paper. It is preferable to start at the poll and end at the nose. Only a little practice is necessary in developing proficiency in obtaining head profiles.

The repeatability of the head contour is of great importance in the study of head form. The repeatability of head profiles of three animals selected at random is shown in figure 3. It is obvious that the first and second profiles of each animal are for all practical purposes identical, even though minor variations which are of little consequence may be perceptible. When the profilometer is placed at the same posi-

tion, held firmly at both ends, and the contour follower is moved slowly and evenly, repeatability is almost perfect. Long, curly, or uneven hair is responsible for most of the irregularities, which may

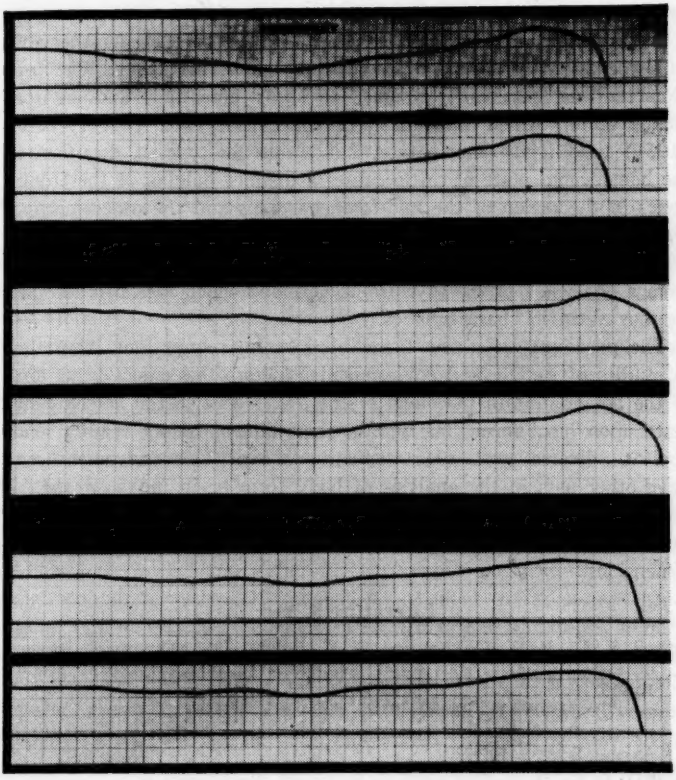

Figure 3. The repeatability of the head profile is shown for three cows selected at random. The two top profiles are from the same individual, the two middle contours from a different individual, and the bottom ones from a third. In each animal the first and second profiles are in almost perfect agreement point for point.

be accentuated if the hair is wet or harbors foreign material. This source of variation can be eliminated, or greatly reduced, with a few strokes of a stiff brush or comb along the path of the contour follower. Wet hair tends to "ball" in front of the contour follower and may

be the cause of slight variations. Certain types of head form are more conducive to slight local errors than others. When the proper precautions are observed, the recording of the profile is entirely mechanical and is not influenced by the operator. After a little experience the operator can tell when he has a "true" profile.

The different parts of the head profile can be correlated rather well with the anatomy of the head and the underlying bones. The profilometer was specifically designed to study hereditary and environmental factors which influence the bovine head. Thus, Gregory *et al.* (1951) used it to demonstrate that a specific type of dwarfism in the homozygous state in cattle causes a distinct bulging of the frontal bones in the region of the mid-forehead. This and the other morphological characters of the dwarfs indicate the anomaly to be a form of cretinism. Carroll *et al.* (1951) have shown that these dwarfs suffer from a deficiency of the thyrotropic hormone which logically accounts for the cretinoid characteristics.

The profilometer is now being used extensively in our laboratory in studies of genetic and environmental factors that affect head form of the bovine, and of the effect of the dwarf gene in the heterozygous state upon head form. The profile on millimeter paper readily lends itself to diverse types of statistical analyses. This instrument may have other uses in the analysis of body form or in industry when it is necessary to obtain an accurate profile or contour of an uneven or undulating surface. It can also be adapted to analyze form in three dimensions.

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THE INFLUENCE OF LEVEL OF FAT AND ENERGY IN THE RATION UPON FEEDLOT PERFORMANCE AND CARCASS COMPOSITION OF FATTENING STEERS

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Texas Agricultural Experiment Station

THE increased use of solvent extraction in processing cottonseed has resulted in the appearance of increased amounts of cottonseed meal containing a low percentage of fat. These products contain approximately one percent fat as compared with about five or six percent found in hydraulic processed meal. It is expected that an increasing percentage of protein supplement will be of the solvent extracted type.

So far as is known at present, fats are not specifically required in the ration of farm animals except as a source of essential fatty acids. Even here, the requirements are uncertain in the case of beef cattle. It is known, however, that fat promotes the absorption of vitamin A and carotene.

Mendel (1930) found that an abundance of fat in rations led to a decidedly larger storage of fat than did an equicaloric intake of carbohydrates. Ellis and Zeller (1930) report, however, that a hog ration containing only 0.15 percent fat resulted in fat storage at a normal rate and the attainment of a normal degree of fatness. Bender and Maynard (1932), working with lactating goats, found that the level of blood lipids showed marked variations which in general followed changes in fat intake. The parallelism between the various lipids with the changes in total lipids was observed in this as in previous studies.

Williams and Maynard (1934) found that in the plasma of lactating goats fed a diet of extremely low fat content, the total lipids, phospholipids and total and free cholesterol decreased gradually and increased when fat was added to the diet.

Jones *et al.* (1942) fed small amounts of crude cottonseed oil to fattening steers and found the difference in gain and yield of dressed beef between lots which received different amounts of cottonseed oil to be indicative of high feed value for the oil. The similarity in gain and finish between a lot fed cotton seed supplemented with cottonseed

meal and a lot fed the same amount of protein and fat in the form of cottonseed meal and cottonseed oil indicated that this protein and fat have approximately the same value whether supplied by cottonseed meal and cottonseed oil or by whole cottonseed.

Raper (1950), in work with beef calves, found when the fat content of the ration was raised from 2 to 5.5 percent, the plasma carotene level rose significantly. Plasma vitamin A, liver vitamin A and carotene were not affected.

Parham *et al.* (1950) fed beef breeding cows hydraulic processed and solvent extracted cottonseed meals. The cows fed hydraulic processed cottonseed meal showed a significantly higher level of blood fat at the close of a 112-day test than did the cows fed solvent extracted meal. No difference was observed in plasma carotene and vitamin A levels in this study.

In view of the scarcity of information on the effect of fat levels in beef cattle rations, it appears desirable to study further the influence of varying amounts of this nutrient in rations for beef cattle.

Experimental

Sixteen high grade Hereford steer calves were used in a 2 x 2 factorial design for this study. These calves were fed individually and maintained in separate pens throughout the course of the experiment. Individual weights were obtained on one day at the beginning and end of the test and every 28 days during its course. Feeding was done once daily during the first 84 days and twice daily during the remainder of the trial. The concentrates and roughage required for each treatment were weighed out once daily. These were thoroughly mixed and weighed into four equal rations for the four steers on each treatment. The cattle had free access to salt and bonemeal.

Blood samples were collected at the beginning, middle and end of the test for Vitamin A, carotene and blood fat analyses. The steers were slaughtered at the end of the trial when conventional slaughter data were obtained. In addition, rib samples were obtained from one side of each carcass and the 9, 10, 11 rib cut was physically separated into fat, lean, and bone. Water and ether extract determinations were made on a sample of lean from the eye muscle. Samples of body fat were also analyzed for carotene and for saturated and unsaturated fatty acids. The methods used in the analysis of the blood and the fat are the same as those previously reported by Parham *et al.* (1950) and Raper (1950).

Results and Discussion

The composition of the feed mixtures used is shown in table 1. It was necessary to vary considerably the composition of the mixtures fed to the different groups of animals in order to provide the different levels of fat and energy desired. The use of crude cottonseed oil in the mixtures for the animals in lots 3 and 4 resulted in approximately a 5 percent difference in level of fat consumed by the various groups of animals. Protein and carotene content of the rations were

TABLE 1. COMPOSITION OF FEED MIXTURES CONSUMED [1]

Lot No.	1	2	3	4
Level of fat	Low	Low	High	High
Level of energy	Low	High	Low	High
Feed mixture, used, %				
Ground sorghum grain	33.78	49.41	16.35	32.41
Cottonseed meal	4.82 [2]	8.72 [3]	8.66 [3]	12.77 [3]
Wheat bran and screenings	19.30	.....	19.24	.....
Cottonseed oil	.....	.....	4.82	4.91
Cottonseed hulls	21.33	21.21	30.09	29.76
Alfalfa hay	20.77	20.66	20.84	20.15
Fat content, %	2.84	2.92	7.55	7.54
Productive energy content, therms [4]	57.85	63.89	59.12	65.18
Protein content, %	12.90	12.20	12.77	12.37
Carotene content, mg./day	384.71	382.69	386.02	373.24
Calcium content, %	0.32	0.28	0.33	0.30
Phosphorus content, %	0.46	0.26	0.45	0.27

[1] Composition of feed mixtures calculated at the end of the trial from average rations consumed.
[2] Solvent extracted meal, 41% protein (cooked).
[3] Hydraulic processed meal, 41% protein.
[4] Calculated according to the method of Fraps (1947).

very similar for all lots (see table 1). It would have been desirable to have a greater difference between the high and low energy levels.

The feed, weight, and slaughter data of the steers are shown in table 2. It may be noted that the average daily gain of each lot of steers was very nearly identical. The steers in lots 3 and 4, however, consumed approximately 2 to 3 pounds less feed per day than the steers on the low fat rations (lots 1 and 2), but they had considerably higher feed efficiency since they required about 100 pounds less feed per 100 pounds gain than the steers in lots 1 and 2. The efficiency of feed utilization was, therefore, higher on the high fat than on the low fat diets and seemed to be independent of the energy level. The lower feed consumption of the cattle in lots 3 and 4 may have been

due to the high level of cottonseed oil in these feed mixtures. This is in accord with previous work (Raper, 1950).

The differences in carcass weight, dressing percentage and hide weight are not great enough to be significant. It is interesting to note, however, that in lots 2 and 4 where a higher energy level was fed, the average carcass grade of the steers was slightly higher though of very doubtful significance.

It may be noted from table 3 that there was no great difference existing in the average weight of the 9, 10 and 11 rib cuts of the

TABLE 2. FEED, WEIGHT AND SLAUGHTER DATA OF STEERS FED DIFFERENT LEVELS OF FAT AND ENERGY

Lot No.	1	2	3	4	
Level of fat Level of energy	Low Low	Low High	High Low	High High	L.S.D. at .05 Level
Av. initial wt. of steers, lbs.	430.00	429.00	428.00	432.00	....
Av. daily gain, lbs.	2.22	2.30	2.22	2.25	0.54
Av. ration consumed, lbs.	18.28	18.91	15.77	16.49	....
Av. feed/cwt. gain, lbs.	824.00	822.00	710.00	733.00	211.60
Av. carcass wt., warm, lbs.	442.00	455.00	453.00	454.00	135.76
Av. dressing percent	62.30	63.10	64.00	63.50	3.02
Av. carcass grade	Low ch.	Av. ch.	Low ch.	Av.ch.	....
Av. hide weight, lbs.	61.75	61.75	61.75	61.75	....

steers fed the different levels of fat and energy in their rations. It is rather surprising to note, however, that the steers in lots 3 and 4 which were fed the high level of fat had a lower percent of fat in the rib cut and a higher percent of lean. This point was further borne out when the ether extract content of the eye muscle was determined. The ether extract content is lower in the eye muscle of the steers fed high fat than in steers fed low fat rations.

There was some variability in color of lean of the rib eye as noted 30 minutes after ribbing down. Values for color were given using Munsell color paddles, meat scale "A" (table 3). These figures emphasized the fact that the carcasses from the steers fed the lower level of fat had lighter, more desirable colored rib eyes. Since the ether extract and marbling were higher on the same carcasses, probably the increased fat tended to dilute the color of lean.

The steers in lots 3 and 4, which were fed high fat rations, had a considerably higher level of plasma Vitamin A and nearly twice as

TABLE 3. PHYSICAL COMPOSITION OF 9–11 RIB CUTS OF STEERS FED DIFFERENT LEVELS OF FAT AND ENERGY

	1	2	3	4	
Level of fat Level of energy	Low Low	Low High	High Low	High High	L.S.D. at .05 Level
Av. wt of rib cut, lbs.	7.74	8.30	7.91	8.01	3.14
Percent fat	34.42	33.62	29.94	30.62	15.04
Percent lean	31.55	31.68	34.78	34.38	6.23
Percent eye muscle	18.91	18.98	20.26	20.00	4.99
Percent edible	84.88	84.28	84.97	85.00	4.57
Percent bone	15.12	15.72	15.03	15.00	4.57
Water content of eye muscle, %	71.46	72.92	72.86	73.88	5.23
Ether extract content of eye muscle, %	5.26	5.42	4.20	3.46	4.82
Color rating of lean	A3.5	A2.5	A4.2	A5.0	4.29
Estimated % of exposed lean surface of rib eye which was fat (marbling)	14	15	12.5	12.2	13.09

high a level of plasma carotene (table 4). These findings are similar to those previously reported by Raper (1950) and by Russell *et al.* (1942). It is most interesting to note that the blood fat levels of the steers fed the high fat rations were approximately three times those of the steers fed the low fat rations. Similar findings have been reported by Parham *et al.* (1950) and by Bender and Maryland (1932).

TABLE 4. DATA ON BLOOD AND BODY FAT OF STEERS FED DIFFERENT LEVELS OF FAT AND ENERGY

Lot No.	1	2	3	4	
Level of fat Level of energy	Low Low	Low High	High Low	High High	L.S.D. at .05 Level
Blood composition					
Vitamin A, p.p.m.	0.49	0.35	0.73	0.55	0.52
Carotene, p.p.m.	0.24	0.22	0.42	0.40	0.15
Fat, mg. %	141.00	168.00	448.00	410.00	139.18
Body fat composition					
Carotene, p.p.m.	0.22	0.19	0.15	0.16	....
Iodine number	42.48	44.95	39.55	39.20	....
Saturated fatty acids, %	59.73	57.73	62.27	63.57	....
Oleic acid, %	38.79	41.02	36.24	25.24	....
Linoleic acid, %	1.27	1.42	1.11	1.58	....
Linolenic acid, %	0.35	0.32	0.32	0.29	....

The carotene level of body fat of the steers fed high fat rations was slightly lower than the carotene level of body fat of steers fed low fat rations. This difference, however, was not great. Iodine number and percent of saturated fatty acids in body fat of the steers in lots 3 and 4 indicate that feeding a higher level of fat in the rations produced a body fat which was more saturated than that found in the steers fed low fat rations. Following this, the percentage of oleic acid (unsaturated) is lower in the body fat of steers in lots 3 and 4 than in the fat of steers in lots 1 and 2. Differences in the percentage of linoleic acid and linolenic acid were very small and not significant. Work reported by Reiser (1951) indicates that rumen flora will hydrogenate polyunsaturated fatty acids. Therefore, in light of this work, it may be that exogenous fat, which must pass through the rumen, is more completely saturated than endogenous fat. Feeding different levels of energy to the various groups of steers seemed to have no bearing upon composition of blood or body fat.

Summary

The effect of two levels of fat and two levels of energy upon rate of gain, efficiency of feed utilization, and carcass composition has been studied with fattening steers. The influence of these factors upon plasma carotene, vitamin A and fat, and upon characteristics of body fat was also determined.

Results of this test indicate that feeding high fat rations to fattening steers had a markedly beneficial effect upon the efficiency of feed utilization. There was no improvement in rate of gain or carcass grade. Feeding higher levels of energy, however, made a very slight improvement in carcass grade.

In this trial, as in previous trials, feeding higher levels of fat significantly improved absorption and utilization of dietary carotene and also brought about a very marked increase in the level of blood fat.

The high fat intake brought about a smaller deposition of fat in the 9, 10, and 11 rib cut, but depot body fat showed a lower iodine number and was, therefore, more saturated.

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UTILIZATION OF D-TRYPTOPHAN BY SWINE [1]

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THE ability of various animals to utilize the unnatural isomer of amino acids is of practical as well as theoretical importance. Commercial manufacture of DL-methionine is a recent accomplishment, and several other amino acids are currently being produced on pilot plant and semi-works scale. The efficiency with which the animal uses the D-form is an important economic concern and may well determine the feasibility of supplementing natural feeds with synthetic amino acids.

It is well recognized that there is wide variation in the degree of use of the unnatural isomer of different amino acids in the same species and also in the use of the same amino acid by various species (Albanese, 1947). Various methods have been employed to determine the quantitative and qualitative use of the D-isomer of an amino acid. Studies on the ability of the unnatural form to promote nitrogen retention and growth would provide information applicable to practical animal feeding problems. Such techniques have been used to measure the utilization of the D-form of tryptophan in human beings (Rose, 1949), in chicks (Wilkening and Schweigert, 1947), in rats (duVigneaud, Sealock and VanEtten, 1932) (Berg, 1934), and in mice (Totter and Berg, 1939). These investigations have shown that D- and L-tryptophan are equally effective for promoting growth in the rat and that the D-form is partially utilized by chicks. A more recent report by Oesterling and Rose (1952), however, indicates only about 75 percent inversion of the D-form in the rat. Little or no use, however, is made of the unnatural isomer for promoting growth in mice or for nitrogen balance in young male human beings. Suggestive evidence that the D-form of tryptophan may be used by swine is contained in the report (Shelton, Beeson and Mertz, 1951) that 0.2

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percent DL-tryptophan promoted as rapid growth in weanling swine as did higher levels. In comparison to the tryptophan needs of other species, this would indicate that the D-isomer is utilized to some degree by swine. A particularly low dietary requirement for this amino acid by swine is not, however, precluded.

In order to investigate further the nutritional requirement of swine for tryptophan and to determine qualitatively whether or not the D-form of tryptophan is utilized, studies were made with "baby pigs" fed a prepared "milk." The milk was supplemented with different amounts of the two isomers as L-tryptophan and as the racemic mixture. Growth, physical condition, and nitrogen retention were used as criteria to estimate the utilization of the D-form as compared to the natural isomer.

Experimental

Two separate nitrogen balance experiments were conducted. Five litter-mate purebred Chester White males were used in the first experiment, and ten litter-mate purebred Duroc-Jerseys (8 females and 2 males) in the second. In both experiments the baby pigs were allowed to nurse the sow for two days. They were then transferred to individual pens equipped with raised floor of one half inch mesh screen which permitted essentially quantitative collection of urine and feces. These pens were in a room maintained at constant temperature of 78° F. They were fed artificial "milks" of defined composition containing 20 percent solids. These milks were prepared by dissolving either lactose or cerelose and gelatine in warm water and homogenizing the mixture with melted lard by means of a medium-size mechanical homogenizer.[4] The other protein component, salts, amino acids (other than tryptophan) and vitamins were then added and the mixture suspended with a Waring blendor (table 1). The milk was refrigerated until used at which time small amounts were resuspended by warming and blending. The baby pigs were fed Ration 1 until they had become accustomed to the new type of food, environment, and feeding techniques.

Ration 2 was fed during the experimental periods. It was designed to be deficient in tryptophan and by calculation contained less than 0.02 percent tryptophan. This was confirmed by microbiological assay of the ration components. A lysine deficiency and a possible methionine lack were corrected by the addition of 1.0 percent DL-lysine·HCl and 0.2 percent DL-methionine. When tryptophan supplements were added,

[4] Homogenette, Model C-10. Homogenette, Inc., Newark, New Jersey.

a solution of either L- or DL-tryptophan was dispensed into a measured quantity of the milk at the time of re-blending prior to feeding.

During collection periods, quantitative collections of urine and feces were made for successive two-day periods. Any rejected food, together with the food wasted, was combined with the feces and analyzed for total nitrogen by Kjeldahl procedure. Urine, which had been collected in a bottle containing an amount of HCl to render distinctly acid, was quantitatively transferred to a volumetric flask of convenient size and made to volume. From this an aliquot was taken for nitrogen analysis. Feed constituents were likewise analyzed for total nitrogen

TABLE 1. RATIONS USED IN DL-TRYPTOPHAN UTILIZATION STUDY *

Ingredients	Composition		
	Ration 1	Ration 2	Ration 3
Crude casein	35	....	....
Zein	....	17.5	17.5
Gelatin	....	17.5	17.5
Lard	41.5	41.5	41.5
Lactose	20.5	19.0	....
Cerelose	....	....	19.0
Salts **	5	5	5
DL-Lysine · HCl	....	1.0	1.0
DL-Methionine	....	.2	.2

* The following vitamins were added to a liter of milk: thiamine 1.1 mg.; riboflavin 1.8 mg.; niacin 10.1 mg.; inositol 26.8 mg.; choline 260 mg.; PABA 5.0 mg.; folic acid 0.13 mg.; viotin 0.025 mg.; pyridoxine 2.0 mg.; calcium pantothenate 71 mg.; ascorbic acid 130 mg.; vitamin B-12 10 mcg.; vitamin A 900 I.U.; vitamin D 120 I.U.; menadione 0.29 mg.; alpha tocopherol acetate 1.5 mg.

** Johnson, B. C., *et al.* 1948. JOURNAL OF ANIMAL SCIENCE 7:486.

to determine the amount of nitrogen offered. Nitrogen retention was calculated by the following formula: Nitrogen retention=(Nitrogen offered)—(Nitrogen of refused feed and feces)—(Urinary nitrogen). The pigs were weighed at two-day intervals.

Experiment 1

This experiment consisted of an adjustment period followed by a depletion period and finally by a series of four eight-day collections during which each animal received each of the treatments. The pigs were fed Ration 1 the first four days of the adjustment period. They were gradually shifted from Ration 1 to Ration 2 during the next six days. The next four days constituted a depletion period in which the pigs were fed Ration 2 without any tryptophan supplementation.

Quantitative collections of urine and feces were begun at this time. The response of the pigs to this tryptophan-deficient ration is shown in table 2.

Following this depletion period, the pigs were kept on this same ration, supplemented with either 0.05 percent L- or 0.1 percent DL-tryptophan. Equal amounts of food were offered, and the quantity was kept sufficiently small to assure that nitrogen intake was relatively constant for all animals. Four successive two-day collection periods (18 to 25 days of age) constituted Trial 1. The response of the pigs to this treatment is shown in table 3. Because of high food

TABLE 2. RESPONSES OF YOUNG SWINE TO TRYPTOPHAN-DEFICIENT RATIONS

Experiments 1 and 2

	Experiment 1	Experiment 2
No. of pigs	5	10
Age (days)	12–17	12–17
Weight change (gms.)	−33.2 ±30.2 [1]	−64.6 ±55.7
Nitrogen offered (gms.)	17.1	26.3
Nitrogen retained (gms.)	−0.05± 0.27	3.9 ± 0.17
Nitrogen retained per day (gms.)	−0.01± 0.05	0.65± 0.02

[1] Standard deviation.

refusals during the first two days, only the data obtained during the last six days are presented. During the next eight days (Trial 2) those pigs which had received a supplement of 0.05 percent L-tryptophan were fed the same ration with 0.1 percent DL-tryptophan and vice versa. Following these trials, two additional eight-day trials (Trials 3 and 4) were conducted, using supplementation levels of 0.1 percent L- and 0.2 percent DL-tryptophan with the same type of design as previously employed. The results of all of these trials are summarized in table 3.

Experiment 2

This experiment was essentially a repetition of Experiment 1, with a larger number of pigs. The experiment began with an adjustment period of eleven days during which the pigs were accustomed to the methods of feeding and gradually transferred from Ration 1 to Ration 2. They were fed Ration 2 without tryptophan supplementation for a six-day period (12 to 17 days). During this time they either lost

TABLE 3. RESPONSE OF YOUNG SWINE TO SUPPLEMENTATION OF TRYPTOPHAN-DEFICIENT RATION WITH L- AND DL-TRYPTOPHAN

Experiments 1 and 2

	Trial 1			
	Experiment 1		Experiment 2	
Level of supplementation	0.05% L-	0.1% DL-	0.05% L-	0.1% DL-
No. of pigs	2	3	4	4
Age (days)	20–25	20–25	18–25	18–25
Weight change (gm.)	169±29 [1]	242±27	280±29	322±12
Nitrogen offered (gm.)	24.9	24.9	36.8	36.8
Nitrogen retained (gm.)	2.9±0.28	3.3±1.53	8.6±1.75	11.5±2.25
Nitrogen retained per day (gm.)	0.48±0.05	0.56±0.25	1.43±0.22	1.92±0.28

	Trial 2			
	Experiment 1		Experiment 2	
Level of supplementation	0.05% L-	0.1% DL-	0.05% L-	0.1% DL-
No. of pigs	3	2	4	4
Age (days)	26–33	26–33	26–33	26–33
Weight change (gm.)	362±22	493±21	236±77	309±60
Nitrogen offered (gm.)	39.5	39.5	39.5	39.5
Nitrogen retained (gm.)	11.9±0.71	12.1±1.06	7.3±2.49	8.9±1.49
Nitrogen retained per day (gm.)	1.5±0.09	1.5±0.13	0.9±0.31	1.1±0.19

	Trial 3			
	Experiment 1		Experiment 2	
Level of supplementation	0.01% L-	0.2% DL-	0.05% L-	0.1% DL-
No. of pigs	3	2	4	4
Age (days)	34–41	34–41	34–41	34–41
Weight change (gm.)	577±21	655±74	116±78	205±52
Nitrogen offered (gm.)	44.3	44.3	38.5	38.5
Nitrogen retained (gm.)	13.1±0.77	13.3±1.98	8.9±1.39	10.8±1.68
Nitrogen retained per day (gm.)	1.6±0.09	1.7±0.25	1.1±0.17	1.4±0.21

	Trial 4	
	Experiment 1	
Level of supplementation	0.01% L-	0.2% DL-
No. of pigs	2	3
Age (days)	42–49	42–49
Weight change (gm.)	830±53	790±73
Nitrogen offered (gm.)	52.2	52.2
Nitrogen retained (gm.)	16.2±1.98	13.7±1.16
Nitrogen retained per day (gm.)	2.0±0.25	1.7±0.15

[1] Standard deviation.

weight or made only slight gains but remained in positive nitrogen balance (table 2).

This depletion period was followed by two successive eight-day trials (18–25 and 26–33 days), similar in design to those described in Experiment 1. Four pigs in each of two groups were fed supplements of 0.05 percent L- and 0.1 percent DL-tryptophan, respectively. The results of these two trials are summarized in table 3.

A third trial was then conducted (34–41 days) in which Ration 3 replaced Ration 2. The essential difference between these two rations was in the carbohydrate constituent. The data obtained during this trial are also presented in table 3.

Discussion

No particular difficulties of a technical nature were encountered in preparing the milk rations or in training the baby pigs to eat them. With a single exception in Experiment 1 (which was removed from the experiment) chronic gastrointestinal disturbances were not encountered. It has been our experience that over-eating is a common cause of difficulty in baby pigs being maintained on such a regimen and the pigs were, therefore, consistently fed a smaller amount of milk than they would clean up. The pigs readily consumed Ration 1 containing casein, but on being transferred to the tryptophan-deficient Ration 2 they sometimes refused feed. When tryptophan was added, a distinct improvement in appetite and other subjective signs were noted in both experiments. No particular difference was noted in the response of the pigs in Experiment 2 when cerelose in Ration 3 was substituted for lactose in Ration 2.

Maintenance of nitrogen equilibrium has long been accepted as a major criterion of the degree of essentiality of an amino acid. In view of the demonstrated essentiality of tryptophan for maintenance of nitrogen equilibrium or growth in a number of higher animals, the failure to observe prompt negative nitrogen balances when baby pigs were transferred from a ration containing casein, which promoted significant nitrogen retention, to one deficient in tryptophan was unexpected. Examination of the data obtained in both experiments, however, showed that while the pigs did not gain weight, they were at most in only slight negative balance. Certain qualifications must be kept in mind in interpreting such data, however. In common with all such studies, any loss of urine or feces or waste of feed resulted in an overestimation of nitrogen retention. Although precaution was taken to minimize losses, it is recognized that some loss cannot be

avoided. This is particularly true when the pigs are young, when they do not have a good appetite, and when feed wastage is high. All of these conditions occurred during the depletion period on the low-tryptophan ration. Even when such factors are taken into account, it is our judgment that these data strongly suggest that the young pig has a lower preformed dietary requirement for tryptophan for maintenance of nitrogen equilibrium than do most other animals for which quantitative requirements have been estimated. Additional unpublished data obtained with older pigs (56 to 65 days of age) as well as continued observations of pigs maintained on the tryptophan-deficient ration for periods as long as three weeks support this view. Further evidence of a low maintenance requirement for tryptophan is found in the observations of Shelton, Beeson and Mertz (1951) who fed a diet somewhat similar in composition to Ration 2 to post-weanling pigs. They reported that during a 28-day period on this ration, pigs weighing about 35 pounds initially lost an average of 2.5 to 3.0 pounds. Maintenance of body weight within such narrow limits would be unlikely, if not impossible, were a severe nitrogen deficient existing. Reber, Whitehair and MacVicar (1951) also observed during experiments on swine affected with hog cholera virus that positive nitrogen balances were obtained on tryptophan-deficient rations until the terminal stages of the disease.

Since the purpose of these experiments was to determine whether or not D-tryptophan was utilized for nitrogen retention, both the L- and DL-isomers were fed at levels below that reported by Shelton, Beeson and Mertz (1951) to be necessary for maximum growth of older pigs consuming a similar ration. Limiting the supply of tryptophan in this manner would tend to permit maximum differences between two groups fed equal amounts of L-tryptophan as the natural isomer and the racemic mixture. Addition of either 0.05 percent L- or 0.1 percent DL-tryptophan resulted in marked improvement in appetite in the pigs which had been receiving the unsupplemented Ration 2. The animals receiving the higher level of total tryptophan showed the more marked subjective improvement; they consumed their food more promptly and with an occasional exception ate all that was offered them. The pigs receiving 0.05 percent L-tryptophan, however, ate with greater reluctance and more frequently rejected a portion of the feeding. Objective differences were less obvious. The weighted averages of gains and nitrogen retention, respectively, Trials 1 and 2 of both experiments are as follows: Trial 1: 32 gm., 0.87 gm. for 0.05 percent L-tryptophan; 40 and 1.15 for 0.1 percent DL-tryptophan.

Trial 2: 36, 1.12; 48, 1.28. It will be noted that the weighted averages favor the higher level of tryptophan intake in the form of the DL-mixture. Due to the variation among animals on the same treatment and to limitation of numbers permitted in this type of experimentation, these differences are not statistically significant. It is our opinion, however, that the combined subjective observations and objective data strongly indicate utilization of the D-isomer. Whether this utilization is relatively high (as in the rat) or low (as in the chick) awaits the availability of the D-form in sufficient quantity to compare it with the natural isomer. On the basis of the data presented here, and other unpublished observations, we would tend to support the view of partial utilization of the D-isomer.

Further evidence of a low-tryptophan requirement for maximum nitrogen retention under these conditions is the data obtained in Trials 3 and 4, Experiment 1. Here, when DL-tryptophan was supplied at the 0.2 percent level, which promoted maximum gain in older pigs (Shelton, Beeson and Mertz, 1951), no improvement in nitrogen retention was found compared to 0.1 percent L-tryptophan. If the level required for maximum rates of nitrogen retention under those conditions was near this latter figure, no demonstrable differences would be expected. Further studies with rations permitting more rapid growth and supplemented with the natural isomer are indicated.

Summary

The degree of utilization of D-tryptophan by swine was studied using baby pigs fed rations deficient in tryptophan and supplemented with either the L- or DL-form of this amino acid. Growth and nitrogen retention were the principal criteria employed to estimate the efficiency of use of the unnatural isomer. Pigs maintained on a ration deficient in tryptophan lost weight, but at most showed only a slight negative nitrogen balance. When this ration was supplemented with 0.05 percent L- or 0.1 percent DL-tryptophan, the animals consumed the ration more readily, growth improved and definitive positive nitrogen retention was found. Averages favored the animals receiving DL-tryptophan, but differences were not sufficiently great to show statistical significance. These combined data support the view that partial utilization of D-tryptophan was effected.

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A COMPARISON OF SWINE FEEDS AS SOURCES OF PROVITAMIN A[1]

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THE usual sources of provitamin A in swine dry-lot rations are yellow corn and alfalfa products. The value of these feeds as sources of provitamin A is quite variable due to differences in the relative quantity and provitamin A activity of these carotenoids. Chemical and biological assay methods for evaluating the vitamin A potency of livestock feeds are not in agreement. The total amount of carotenoids in a feed may be determined by chemical analysis but this does not give a true estimate of the provitamin A activity.

Investigations by Hoefer and Gallup (1947), Rubin and Bird (1941) and King *et al.* (1940) showed that carotene from alfalfa was more readily available to sheep, chicks and cattle respectively than crystalline carotene in oil. Mangelson *et al.* (1949) reported that cockerels fed 15 percent sun-cured alfalfa containing 7.6 γ carotene per gram of feed stored less liver vitamin A than those fed 5 percent dehydrated alfalfa containing 6.1 γ carotene per gram of feed. Frey and Wilgus (1949) found that chickens utilized the carotenoids in fresh alfalfa more efficiently than those in dehydrated alfalfa meal. Hostetler, *et al.* (1935) reported that 5.6 percent alfalfa fed to fattening pigs as the sole source of carotene was sufficient for good daily weight gains. Hentges *et al.* (1949) reported that 3 percent dehydrated alfalfa meal or dehydrated pelleted alfalfa was sufficient for good weight gains and maintenance of blood and liver levels of vitamin A but that 3 percent sun-cured alfalfa failed to maintain normal plasma vitamin A levels in fattening pigs. Guilbert *et al.* (1937) noted that 25 to 39 γ carotene/kg. body wt. daily fed as alfalfa meal was sufficient to bring about good growth and some storage of vitamin A in the livers of vitamin A deficient pigs. The minimum daily requirement of young pigs for crystalline carotene in cottonseed oil has been reported by Hentges *et al.* (1952) to be 25 γ/kg. body weight when liver and blood plasma vitamin A concentrations were the criteria used.

Kemmerer and Fraps (1943) reported that the purified carotene fraction of alfalfa meal was largely a mixture of all-trans-B-carotene and its partially cis isomers because no significant quantities of alpha

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carotene were detectable. Relatively low nutritional values have been assigned to the cis isomers, for example, neo-B-carotene B has 53 percent of the growth-promoting activity of all-trans-B-carotene for rats (Deuel, 1945a) while neo-B-carotene U has been reported to have 25 percent (Kemmerer and Fraps, 1945) or 38 percent (Deuel, 1944) of the activity of all-trans-B-carotene when fed to rats.

In recent years, a large part of the alfalfa used in swine feeds has been processed by dehydration and some has been pelleted. Bickoff *et al.* (1949) reported that as much as 60 percent of the carotene from dehydrated alfalfa meal existed in partially cis forms (neo-B and neo-U) while only small amounts of these isomers were present in the fresh material. In their opinion, this demonstrated that stereoisomerization of carotenoids occurred during the dehydration process. Sun-curing the alfalfa resulted in a lesser degree of isomerization. The provitamin A activity of feeds containing these stereoisomers would undoubtedly be less than that calculated from a total carotene analysis by chemical methods.

In view of these reports, alfalfa products, yellow corn, and crystalline carotene were compared as sources of provitamin A for swine by feeding vitamin A deficient pigs quantities of test feeds providing equivalent amounts of total carotenoids. Deficiency symptoms, daily weight gains, and blood plasma concentrations of vitamin A were used to indicate the state of vitamin A nutrition of the animal.

Experimental

This experiment was divided into two periods, a depletion period during which a diet low in carotenoids was fed and a supplementation period during which the vitamin A deficient pigs were fed the depletion diet plus quantities of the test feeds furnishing equivalent amounts of total carotenoids. Seventeen grade Hampshire pigs, three weeks of age, were used in this experiment. They were kept in metal metabolism cages in a room where the temperature was thermostatically controlled at a minimum of 70° F. and the air was constantly circulated. The depletion diet consisted of hulled oats 79 percent, meat scraps 10 percent, dried skim milk 10 percent, APF supplement [3] 1 percent, and irradiated yeast 0.2 oz. per 100 lb. feed. Supplementation was commenced when the blood plasma vitamin A levels of the pigs were depleted to 5 γ/100 ml. plasma. The finely ground test feeds were mixed with a small portion of the depletion ration and the pigs were individually fed daily.

[3] Lederle APF Feeding Supplement-5, Lederle Laboratories of American Cyanamid Co., Pearl River, New York.

The alfalfa used in this study was third cutting alfalfa harvested just prior to blooming. Quantities of freshly cut alfalfa from the same field were sun-cured or dehydrated and a portion of the dehydrated alfalfa was pelleted. The alfalfa pellets were cooled immediately because a previous study of several commercial pelleted alfalfa products revealed a consistently low carotenoid content, suggesting losses due to the heat created during pelleting.

The crystalline carotene [4] in cottonseed oil was administered orally by syringe daily. The test feeds were analyzed periodically for total carotenoid content by the method of Cooley and Koehn (1950). Blood plasma vitamin A content was determined either weekly or every two weeks by the method of Kimble (1939) and weights were recorded weekly.

Results and Discussion

The pigs were fed the depletion diet for nine weeks before the average blood plasma vitamin A levels were depleted to 5 γ/100 ml. No gross deficiency symptoms were evident at the time the pigs were allotted for supplementation. The total carotenoid content of the feeds at the start of supplementation was as follows: dehydrated alfalfa pellets, 193 γ/gm.; dehydrated alfalfa hay, 193 γ/gm.; sun-cured alfalfa hay, 36 γ/gm.; yellow corn, 2.1 γ/gm.; and the purified carotene in cottonseed oil, 220 γ/ml.

The data obtained during the supplementation period are summarized in table 1.

Excellent average daily weight gains were recorded for all lots. After two weeks of supplementation, a marked increase of blood plasma vitamin A was noted in the lots receiving dehydrated alfalfa meal and ground alfalfa pellets while a lesser increase was noted in the lots fed yellow corn and ground sun-cured alfalfa hay. At the end of four weeks of supplementation, the blood plasma vitamin A levels of the lots receiving dehydrated alfalfa meal, ground alfalfa pellets and purified carotene in oil were within the range of values observed in apparently normal pigs. The average plasma vitamin A levels of the lots receiving sun-cured alfalfa and yellow corn did not enter this range of apparently normal values until nine weeks after supplementation was started. Since all pigs were fed quantities of feed which provided equivalent amounts of carotenoids, the differences in plasma vitamin A response must be attributed to differences in the provitamin A activity of carotenoids in each feed and perhaps the rate of release

[4] Purified crystalline carotene (80–85 percent beta form) derived from carrots. Purchased from Nutritional Research Associates, Inc., So. Whitely, Indiana.

of these carotenoids from the plant material. The superiority of the dehydrated alfalfa products over purified carotene in oil is attributed to differences in the content of beta carotene. The carotenes in alfalfa are all of the beta form while the purified carotenes from carrots were only 80 to 85 percent beta carotene. Hence, the purified crystalline carotene contained a considerable amount of alpha carotene which has been reported to possess 53 percent of the vitamin A activity of beta carotene for growth of rats (Deuel *et al.*, 1945b) and only 25

TABLE 1. THE PROVITAMIN A ACTIVITY OF VARIOUS SOURCES OF CAROTENOIDS FED TO VITAMIN A DEFICIENT PIGS

Lot	No. Pigs	Carotenoids per kg. Body wt./da.	Sources of Carotenoids [2]	Av. Plasma Vitamin A During Supplementation			Av. Da. Gain [1]
				Initial	2 Wks.	9 Wks.	
				γ/100 ml.	γ/100 ml.	γ/100 ml.	lb.
I	3	25 γ	Pelleted, dehyd. alf.	5.0	17.6	21.6±0.9	1.14
II	3	25 γ	Dehyd. alf.	5.0	16.0	18.5±1.6	1.12
III	3	25 γ	Sun-cured alf.	5.0	7.7	17.2±0.8	1.14
IV	3	25 γ	Yellow corn	5.0	7.9	17.3±1.6	1.14
V	5	25 γ	Carotene in cottonseed oil [3]	5.0	13.0	22.6±1.6	0.94

[1] During supplementation period only.
[2] Daily supplements individually fed.
[3] Administered orally each day.

percent for liver vitamin A storage by rats (Johnson *et al.*, 1947). The poor response of the lot receiving yellow corn was anticipated because cryptoxanthine comprises a great percentage of the total carotenoids of yellow corn. The provitamin A activity of cryptoxanthine has been estimated to be only 57 percent as effective as beta carotene in promoting growth of rats (Deuel *et al.*, 1945c). In comparing the response of the lots receiving dehydrated alfalfa and sun-cured alfalfa, it is necessary to point out that 5 grams of dehydrated alfalfa meal supplied the daily carotene requirement for a 90-pound pig while 32 grams of ground sun-cured alfalfa hay was required to provide the same amount of carotenoids. Thus, the release of carotenoids from the plant material, the relative amounts of carotenoids remaining in the leaves as compared to the lignified stems, and the effect of bulk upon the efficiency of carotene utilization tend to complicate this comparison.

In a previous experiment, the effect of bulk appeared to have a beneficial rather than a depressing effect on carotene utilization, however, in this experiment the bulky material was not the carotenoid carrier. Two lots of vitamin A deficient pigs were fed low-carotenoid rations which were otherwise thought to be nutritionally adequate for growth. Each ration contained the same level of protein and the same ration ingredients except that the bulk was increased in one by the inclusion of 20 percent by weight of ground oat straw. These rations were fed *ad libitum*. Equivalent amounts of purified carotene in oil were administered orally by syringe at the rate of 17.5 γ per kilogram body weight daily. After four weeks on this level of supplementation, the plasma vitamin A levels of the lot receiving the bulky ration had shown the greatest increase but the plasma levels were still sub-normal, hence, the supplement was increased to 25 γ carotene/kg. body weight daily. In two weeks, the average plasma vitamin A levels had risen to 15 γ/100 ml. in the lot fed the ration containing 20 percent gr. oat straw and to 12 γ/100 ml. in the control lot. There were no differences in average daily gains between lots after the first week of supplementation. In view of these limited data, it appears that the bulkiness of the ration may actually enhance carotene utilization; hence, the rate and extent of release of carotene from the sun-cured alfalfa used in this experiment appears to be the major factor in explaining the differences in results. The degree of stereoisomerization of carotenoids in the alfalfa products, as the result of processing, was not determined, thereby leaving another source of variation to be investigated.

These data suggest a need for the use of improved chemical or chromatographic methods for estimating the relative amounts of various carotenoids in alfalfa products and commercial swine feeds. Such methods should separate the total carotenoid content into the various forms and isomers of the carotenoids, thereby affording a more nearly accurate estimation of provitamin A activity.

Summary

Carotenoids in sun-cured alfalfa hay, dehydrated alfalfa meal, dehydrated alfalfa pellets, yellow corn, and crystalline carotene in cottonseed oil when fed at the rate of 25 γ/kg. body weight daily to vitamin A deficient pigs were adequate for optimum weight gains and eventual restoration of apparently normal blood plasma vitamin A levels. However, the rate of recovery of normal plasma vitamin A levels varied with the source of carotenoids. The feeds used showed the following order of effectiveness as sources of provitamin A: dehydrated alfalfa

meal and pellets, crystalline carotene in cottonseed oil, sun-cured alfalfa hay and yellow corn.

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FAT, FAT CONSTANTS, AND PHOSPHOLIPID CONTENT OF SOW'S MILK [1]

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RECENT investigations concerning the nutrition of the baby pig, in direct feeding studies employing synthetic milks, demonstrate a need for a more detailed analysis of the composition of sow's milk than that which appears in the literature. The value of fats in nutrition from a caloric point of view has long been accepted. Recently, however, fats have been shown to be of qualitative as well as quantitative importance in nutrition (Burr and Barnes, 1943; Burr and Burr, 1929; Hanson and Burr, 1946; Witz and Beeson, 1951). Comparative studies of animal and vegetable fats with postweanling animals indicate that the common animal and vegetable fats are just about equal in over-all nutritive value (Deuel, 1949a, 1949b; Hilditch, 1947). Early work with young calves in which either "filled" milks or synthetic milks were used (Bate *et al.*, 1946; Gullickson *et al.*, 1942; Jacobson *et al.*, 1949) consistently indicated inferior results when diets containing oils from plant sources were fed. Currently, Kastelic *et al.* (1950) demonstrated that cottonseed oil, when thoroughly homogenized with an appropriate amount of phospholipid, served as an excellent source of fat in a semisynthetic milk diet for colostrum-free calves. Other work at this station by Sheffy *et al.* (unpublished data) indicated that lard was superior to butter as a source of fat for 2-day-old pigs receiving a semisynthetic milk.

Thus, in order to learn better how to simulate natural composition in the preparation of synthetic milks for baby pigs, this study was undertaken. The fat and phospholipid content of sow's milk is reported. Further, in an effort to determine the type and character of sow's milk-fat, various fat constants were determined.

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TABLE 1. FAT, PHOSPHOLIPID CONTENT, AND FAT CONSTANT DATA OF PASTURE-LOT SOW'S MILK

Stage of Lactation	Fat	Phospholipid		Saponification No.	Hehner No.	Iodine No.
		mg./100 g. Milk	% of Fat			
4–15 day	7.73±0.30 [1]	110.2±9.4	1.44±0.12	191.18±0.73	92.59±0.33	68.32±1.11
15–38 day	7.25±0.53	100.1±6.8	1.39±0.10	187.90±3.73	91.29±1.52	70.43±2.09

[1] Mean values±the standard error of the mean.

Experimental Procedure

The work reported in this study will be discussed in three separate parts since each of the groups of sows was handled under different systems of feeding and management.

Part I

Twelve grade Hampshire sows, six between the 4th and 15th day of lactation and six between the 15th and 38th day of lactation, were milked after injection of 1 cc. of pitocin into the ear vein. The fresh milk samples were analyzed for the fat and phospholipid content. The remaining milk was extracted immediately and the saponification number, Hehner number, and iodine number determinations were made on the extracted fat. Summary of the results appears in table 1. These sows were on excellent ladino-alfalfa pasture during the gestation period. During the last half of the gestation period they were fed first one, then two ears of corn per sow per day. Seven days prior to farrowing they were moved to the farrowing barn and self-fed the following ration: 15 parts alfalfa, 15 parts of a 40 percent protein commercial hog supplement, 5 parts corn, 15 parts wheat, 48 parts oats, and 1 part each of $CaCO_3$ and trace mineralized salt.

Part II

Nine grade Chester White-Spotted Poland China sows were used for this study. The sows were in dry lot on a ration consisting of 80 parts yellow corn, 5 parts animal protein, 5 parts alfalfa, 9 parts soybean oil meal, and ½ part each of $CaCO_3$ and trace mineralized salt. The sows were self-fed until a few days prior to farrowing when they were hand-fed the same ration. Milk samples were taken on the 1st, 15th, and 30th day. The method of sampling was the same as previously described. Fat and phospholipid determinations were made immediately after milking. The remaining milk was frozen and stored at 0° C. When all the samples were collected, the fat was extracted and the determinations of the following fat constants were made: saponification number, Hehner number, and the iodine number. The results of the work are summarized in table 2.

Part III

Four purebred Poland China and six purebred Chester White sows were milked on the 1st, 15th, and 30th day of lactation. Pitocin was used as described previously. The milk was frozen and stored at 0° C.

TABLE 2. FAT, PHOSPHOLIPID CONTENT, AND FAT CONSTANT DATA OF DRY-LOT SOW'S COLOSTRUM AND MILK

Stage of Lactation	Fat	Phospholipid		Saponification No.	Hehner No.	Iodine No.
		mg./100 g. Milk	% of Fat			
Colostrum	11.52±0.71 [1]	165.7±16.6	1.49±0.15	190.46±1.13	91.39±0.48	81.86±1.47**
15-day	10.42±0.55	162.8±14.9	1.60±0.16	190.79±1.18	91.84±0.26	68.90±3.39
30-day	8.73±0.49	153.5±13.9	1.77±0.16	192.58±0.92	91.12±0.60	66.32±2.79

[1] Mean values±the standard error of the mean.
** Significant at 1% level.

After three months the samples were thawed, the fat extracted, and the following fat constants were determined: saponification number and iodine number. The results are summarized in table 3.

Prior to farrowing these sows were on good alfalfa-brome-ladino pasture and were self-fed soft ear corn plus a mixture consisting of 46 parts of ground corn, 30 parts oats, 17 parts wheat middlings, 3 parts linseed meal, 3 parts tankage, and a half part each of $CaCO_3$ and trace mineralized salt. Three days before farrowing the sows were brought into the farrowing barn and hand-fed the following mixture: 20 parts ground corn, 20 parts oats, 20 parts wheat middlings, 15 parts wheat bran, 8 parts linseed meal, 4 parts tankage, ½ part calcium carbonate, ½ part trace mineralized salt, and 12 parts alfalfa leaf meal. The sows were limited fed for a few days after farrowing and then full fed the above mixture.

TABLE 3. THE MEAN SAPONIFICATION AND IODINE NUMBERS OF THE MILK FAT OF SOWS GESTATED ON PASTURE

Items Compared	Colostrum	15-Day	30-Day
Saponification No.	192.03 ±4.02 [1]	185.16±4.02	186.74±3.63
Iodine No.	80.53**±1.98	67.74±1.65	68.93±1.60

[1] Mean values±the standard error of the mean.
** Significant at 1% level.

Methods

The fat content was determined employing the Mojonnier technique. The tared fat sample resulting from the fat determination was wet ashed and phosphorus content was determined using the Fiske-Subba-Row colorimetric method (1925). The factor 25.94 was used in converting phosphorus to phospholipids, which assumes that the phosphorus found was in the form of lecithin of the stearyl-oleyl type.

The fat was extracted from the milk by a modified Roese-Gottlieb extraction method which was found suitable for the large quantities of milk involved. The fat constants were determined according to the official methods (A.O.A.C., 1950).

Results and Discussion

Part I

A trend for the fat content to decrease with the stage of lactation was in evidence. The average fat values of 7.73±0.30 and 7.25±0.53

percent, for 4- to 15- and 15- to 38-day periods respectively (table 1), were intermediate between the values reported by Bowland *et al.* (1949) for pasture-fed sows and those reported by Braude *et al.* (1947).

The phospholipid content, when expressed either as mg. per 100 grams of milk or as percentage of the fat, did not change significantly during the period studied, although there was a slight decrease in the total amount of phospholipid as lactation advanced.

The fat constants were not significantly different for the various stages of lactation. The trends, however, indicated a lower saponification number and a slightly higher iodine number for the milk fat of sows in a more advanced stage of lactation.

Part II

A summary of the fat, phospholipid content, and fat constant data for dry-lot sows at three stages of lactation appears in table 2. The fat content declined steadily from colostrum to 30-day milk. Similarly, the total phospholipid content (mg./100 gm. milk) declined with advance of lactation. The decrease in phospholipid, however, was not of the same magnitude as the decrease in fat content. Consequently, when the phospholipid content was expressed as percentage of the fat content, there was an apparent inverse relationship between the fat and phospholipid content. Since phospholipids form a monomolecular layer on the fat particles (Palmer and Samuelson, 1924), this relationship may in part be explained by a decrease in particle size with stage of lactation. On the basis of the theory as advanced by El Rafey, the phospholipid content associated with milk fat would be inversely proportional to the diameter of the fat globules.

The fat content of the normal milk from the dry-lot sows in part II (table 2) was considerably higher than that of the pasture sows (table 1). Bowland *et al.* (1949) made similar observations. There are many factors that may influence the fat content of cow's milk (Reece, 1943). Most of these factors no doubt are involved in variations that are found in sow's milk.

The animal body tends to deposit ingested fat when there is a surplus of food materials, and the ingested fat is not needed for energy requirements. Willett and Maruyama (1946) have shown that an increased fat content of the ration raised the amount of fat in the milk of sows. Lucas *et al.* (1943) working with dairy cattle reported an increase in milk production when rations with higher than normal levels of fat were fed but observed little increase in fat content of milk. The sow seems to have but a limited ability to maintain a

normal level of fat in its milk. It may be able to maintain a minimum level by restricting the flow of milk but the reverse may not be possible. The sow, thus, seems to be more dependent upon ingested and depot fats to maintain the fat level of her milk than the cow since comparable fatty acid synthesis, as is found in the rumen of the cow, has not been shown to be present in monogastric animals. Thus, the level of feeding (caloric intake) during gestation and lactation by directly affecting the degree of fatness of the animal may be an important factor in indirectly affecting the fat content of the milk of swine.

The dry-lot sows self-fed a ration of 80 percent yellow corn (part II) were considerably fatter than the pasture-gestated sows in part I. This is a common observation in pasture vs. dry-lot gestated sows unless the energy intake of the dry-lot sows is limited.

The Hehner numbers and the saponification numbers for colostrum, 15-day, and 30-day milk fat were not significantly different. The saponification number, however, was more variable than the Hehner number. The iodine number of colostrum fat was consistently high, dropping sharply to 15-day, with a further slight decrease to 30-day milk fat. Thus, colostrum fat was significantly more unsaturated than fat at the 15th or 30th day of lactation. No consistent breed differences were observed.

Part III

The mean iodine number for colostrum fat (table 3) was significantly higher than that of 15- and 30-day fat. There was a drop in the saponification number from colostrum to 15-day fat, with a subsequent slight rise to 30-day fat. The consistently high iodine number of colostrum along with a higher saponification number cannot be readily explained. It is likely, however, that colostrum fat may contain more of the essential fatty acids than later milk fat. The high vitamin A content of colostrum may also be a contributing factor, as far as the iodine number is concerned.

In general, the fat constants of sow's milk fat as stated are characterized by the existence of considerable individual variability among sows regardless of ration or stage of lactation, the iodine number of colostrum fat being the single exception. Small amounts of soluble fatty acids were found in most samples, but the results were too variable to be of significance. The only report found in the literature on the composition of sow's milk fat is the paper by Laxa (1931) in which he reports the following values: solidification point

17.0–18.5° C., fusion point 28° C., refraction 52° at 40° C., saponification number 139.9, Hehner number 93.7, iodine number 58.2, Reichert-Meissl number 2.1, Waters-Polenske number 1.2. The values for saponification and iodine number reported by Laxa are considerably lower than those reported in this paper. Laxa, however, made no mention of the conditions of his study.

A comparative study of fat constant values of various fats and oils (Lange, 1949) reveals that lard is very similar in composition to sow's milk fat. The following are average values for lard reported in the Handbook of Chemistry (Lange, 1949): saponification number 193–198, soluble acids nil, Hehner number 93–95, iodine number 62.5–79.0, and Reichert-Meissl number 0.2. This suggests that the mammary gland of the pig apparently exerts little or no change to depot fats as they are being utilized in the elaboration of milk fat. A similar situation has been reported for the whale (Klem, 1935; Schmidt-Nielsen and Frog, 1933) where there is little or no difference between blubber fat and the fat of whale milk.

Summary and Conclusions

The fat and phospholipid content of sow's colostrum and normal milk has been studied. A qualitative study of the fat of colostrum and milk of sows was also made. The effects of pasture versus dry-lot feeding during the gestation period were observed on the above criteria at different stages of lactation. The data warrant the following conclusions:

1. The mean values for fat of the sows fed in dry lot during the gestation period were higher than those of sows fed in pasture during gestation.

2. Total fat and phospholipid content decreased with stage of lactation but the phospholipid content, when expressed as percent of the fat, did not vary significantly.

3. The iodine number of colostrum fat was significantly higher than that of 15- and 30-day milk fat.

4. The saponification number and Hehner number of sow's milk fat were relatively constant and were not significantly affected by feeding or stage of lactation.

5. The composition of sow's milk fat, as indicated by fat constants, closely resembles that of swine depot fats or lard.

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ABSTRACTS OF PAPERS TO BE PRESENTED AT THE FORTY-FOURTH ANNUAL MEETING OF THE AMERICAN SOCIETY OF ANIMAL PRODUCTION

The meetings are scheduled to be held at the Hotel Sherman in Chicago on November 28 and 29, 1952. Abstracts have been submitted for the following papers.

Breeding and Genetics Section

W. J. Tyler, *Chairman*

LIVE ANIMAL SCORES AND SPLIT CARCASS MEASUREMENTS AS INDICATORS OF CARCASS VALUE IN SWINE. R. L. Arthaud and G. E. Dickerson, *University of Missouri.*

Descriptive scores of live conformation and carcass data studied included 437 pigs of 4 purebred strains and 23 strain crosses of 5 breeds during three seasons. Within season and breeding groups, higher yields of lean and of loin equivalent and lower yields of fat were correlated with higher live scores for body length (.19, .27, and —.27), leg length (.31, .31, and —.34), trimness of jowl (.21, .21 and —.22), smoothness of shoulder (.12, .15, and —.16), quality (.21, .31 and —.15), breeding (.18, .32 and —.17), market (.17, .30 and —.22), and balance (.12, .22 and —.06), but with lower scores for body width (—.32, —.32 and .41), body depth (—.32, —.30 and .42), and flatness of back (—.12, —.09 and .21), and with lower estimated U.S.D.A. grade (—.29, —.21 and .20) and estimated backfat thickness (—.20, —.16 and .27). Higher scores for plumpness of ham were associated with more skinned ham (.12), fat cuts (.11) and loin equivalent (.06), but not with lean cuts (.02). Scores for greater arch of back and more level rumps were correlated with slightly less loin equivalent (—.05). The multiple correlation of adjusted loin equivalent with nine descriptive scores plus carcass backfat thickness was .56; omitting backfat reduced it only to .51, and use of only width, shape of back and ham and quality scores only gave R=.50. Use of backfat thickness and carcass length was inferior to combinations of live scores and no better than for backfat thickness and live score for length (R=.44). Estimation of carcass composition from live animal scores was considerably more accurate between than within strains and crosses.

COMPARATIVE LAMBING DATES OF UNTREATED EWES AND EWES TREATED WITH VARIOUS HORMONE PREPARATIONS. T. Donald Bell and Walter H. Smith, *Kansas State College.*

Approximately 1000 commercial ewes of different ages and types, and 400 purebred ewes of three different breeds, were included in the study. Three hormone preparations available on the market and similar to others being offered for sale were used. One of these was a gonadotropic hormone prepared from dried sheep pituitaries; another was a synthetic estrogenic hormone; and the third

product used was a naturally-occurring estrogenic material obtained from pregnancy urine. Different groups of ewes in each flock were given these preparations during the early part of June, 1951, and their subsequent breeding and lambing dates compared with groups within each flock that were untreated. The two estrogenic hormones generally produced heat or estrual periods following injection, but the ewes commonly did not settle during this artificial heat period. Only a small percentage of the ewes injected with the gonadotropic material came into heat following injection, but a large proportion of those that came into heat conceived following breeding during this period. The exact percentage responding to treatment could not be checked accurately because some of the ewes were breeding normally with or without injection during this period. The hormones generally failed to produce earlier or more uniform lamb crops, and one of the hormones used apparently interfered with normal reproductive activities and produced a later and less uniform lamb crop than was obtained from the uninjected ewes.

REPEATABILITY OF PRODUCTION IN RANGE BEEF COWS. M. P. Botkin and J. A. Whatley Jr., *Oklahoma A & M College.*

The data investigated were 603 weaning weights and 620 birth weights of calves produced by 151 range Hereford cows in the experimental herd at Stillwater during the eight year period from 1944 through 1951. Also, weaning weights and birth weights of 98 calves from 49 cows at the Fort Reno experiment station were analyzed. The effects on birth weights and weaning weights of age of calf, sex of calf, age of dam and year were studied, and correction factors were devised to adjust weights to a comparable basis. Gains from birth to weaning were determined by subtracting corrected birth weights from corrected weaning weights. For the group of cows at Stillwater, all of which calved first at three years of age, repeatability was determined by two methods: intraclass correlation between weights or gains of calves produced by the same cow and regression of later records from the first toward the herd average. Estimates of repeatability were as follows: for weaning weight .43 and .49, for birth weight .18 and .14, for gain from birth to weaning .38. For the group of cows at the Fort Reno Station, all of which calved first at two years of age, the correlation between weaning weights of first and second calves was .66. The correlation between birth weights of first and second calves was .25, and the correlation between gains from birth to weaning of first and second calves was .69.

EARLY WEANING OF BEEF CALVES FOR EARLIER EVALUATION OF RATE AND ECONOMY OF GAIN. J. Buric, W. W. Green and J. E. Foster, *University of Maryland.*

Aberdeen Angus and Hereford steers and heifers were weaned at 90 and 180 days of age and fed individually until 370 days of age in order to establish feeding and management practices preliminary to a study of the possibility of developing a technique for an early evaluation of rate and economy of gain for beef calves. From 90 to 180 days the calves weaned at the younger age were fed No. 1 alfalfa hay and a commercial calf starter and from 180 to 370 days all calves received No. 2 alfalfa and a grain mixture. Hay and grain were fed separately and *ad libitum*. Sixty-two calves were used during a period of three years. An analysis of variance of weight by 28 day periods indicated significant differences between weaning age groups during periods immediately following respective weaning. Differences between years were not important. No statistically significant differences were found between breeds but some differences between

sexes were found. Similar situations were found for T.D.N. consumption. Calves weaned at 90 days grew more uniformly than the 180 day calves when growth from 118 to 180 days was compared with growth from 202 to 370 days and the standard errors of estimate were smaller for the regressions of the 90 day calves. The correlations and regressions between T.D.N. and average weight per feeding period from 202 to 370 days of age were in the ranges of 0.80 to 0.86 and 0.40 to 0.44 respectively. Through that age range both weight and T.D.N. consumption increased in a rectilinear manner. The feeding and management practices developed are satisfactory; the calves develop normally and no unusual conditions were noted.

THE COMPARATIVE PERFORMANCE OF SWINE SELECTED FOR FOUR GENERATIONS ON HIGH OR LOW PLANE OF NUTRITION. R. E. Christian, H. R. Black and M. E. Ensminger, *State College of Washington.*

A foundation herd was established in 1947 by mating Danish Landrace boars with Chester White gilts. The resulting offspring were divided, at weaning time, into two groups; one group (called high plane, H.P.) was full fed, the other group (called low plane, L.P.) was fed 70 percent of full feed. The two groups have been continued for four additional generations; all selections and matings have been made within groups. Breeding stock has been selected as the animals reach 150 pounds on the basis of the following index: (No. pigs farrowed alive) +2 (No. pigs weaned) +35 (Avg. daily gain from weaning to 150 pounds). As the pigs reach 150 pounds they are hand-fed until farrowing to prevent H.P. animals from becoming obese. The performance of the two groups in the second, third and fourth generations is as follows: Avg. No. born alive, H.P.—10.2, 7.5, 10.1 and L.P.—10.3, 8.6, 9.0; Avg. No. weaned, H.P.—6.2, 3.9, 7.9 and L.P.—7.0, 5.2, 7.1; Avg. daily gain in pounds from weaning to 150 pounds, H.P.—1.24, 1.45, 1.44 and L.P.—0.68, 0.80, 0.98.

GENETIC COVARIATION AMONG CHARACTERISTICS OF SWINE. C. Clark Cockerham, *Iowa State College.*

The two primary purposes of this study were (1) to investigate the heritability of size of litter and of growth in swine and (2) to investigate the genetic relationship between size of litter and growth. The study also yielded information on phenotypic variances and correlations. Size of litter was measured by number of pigs at three different ages: birth, 56 days and 154 days. Growth was measured by weight at 56 days and 154 days. The data came from twelve inbred lines of Poland China swine and one inbred line of Danish Landrace and encompassed a total of 1,980 litters. The analyses of the variation were within groups in which all individuals were of the same line, had dams of the same age and were contemporary with respect to year and season. Heritability was estimated as twice the regression of offspring on dam. The numerical values thus obtained were as follows: number born, $-.11 \pm .07$; number at 56 days, $-.09 \pm .08$; number at 154 days, $-.15 \pm .08$; weight at 56 days, $.03 \pm .08$; weight at 154 days, $.07 \pm .10$. Tentatively, heritability of size of litter (in the additive sense) is concluded to be zero or very nearly zero. Even for weight, the estimates of additive heritability are too small to be significantly different from zero on this volume of data. Regressions of one trait for the offspring on another for the dam were also computed. Litter size and weight were indicated to be positively related genetically. Additive genetic effects for growth before weaning appeared to be uncorrelated with those for growth after weaning.

THE EFFECT OF THREE SUCCESSIVE CROSSES OF PUREBRED RED DANE SIRES ON MILK AND BUTTERFAT PRODUCTION. L. J. Cranek, N. P. Ralston and A. C. Baltzer, *Michigan State College.*

Since 1940 eighty-four Red Danish sires from the U.S.D.A. Bureau of Dairy Industry were loaned to dairymen in Michigan who were willing to cooperate fully with the principles of the Red Dane project designed to increase the number of females available for the proving of young Red Dane sires in order to study more fully the genetic constitution of the parent Red Dane herd. This report includes data on 1362 cows, which averaged 354 lbs. butterfat, that were mated to these Red Dane sires. These cows were composed of the following breeds and numbers: Jersey 149, Brown Swiss 35, Holstein-Friesian 335, Mixed 169, Guernsey 368 and Shorthorn 302. The mean butterfat production and standard deviation for each breed was 396±91, 386±70, 380±99, 346±87, 339±77 and 322±76 lbs. respectively. The mean butterfat production of the graded-up daughters of these cows was as follows: first cross 372±80, second cross 373±78, and third cross 374±82. The differences in mean production between crosses were not significant. However, the increase in the mean butterfat production of the crosses was significantly greater ($P<0.01$) than the mean of the foundation cows. This significant increase was due to the preponderance of low producing foundation cows of the Guernsey, Mixed and Shorthorn breeds. The differences between the mean butterfat productions of the crosses and those of other foundation breeds were not significant. The differences in mean milk production parallel those of butterfat production. In all instances the butterfat percentage of the crosses approached the mean of the parents.

INFLUENCE OF INBREEDING ON PRODUCTION. H. P. Davis and Mogens Plum, *University of Nebraska.*

This study concerns the Winterthur herd of Holsteins and represents more than a quarter of a century of inbreeding of the Ormsby family. It is particularly significant because the records were made under as uniform environmental conditions as are possible over a long period; and during the major part of the time, they were made on a twice-a-day basis. All records were corrected to a mature, 2x, 305 day basis for the study and Wright's formula for inbreeding used. Twenty bulls were involved and their 630 daughters averaged 8.14 percent of inbreeding and 14,338 lbs. milk, 529 lbs. of fat, 3.69 percent. Of the 188 daughters with no inbreeding, the production was 13,934 lbs. milk, 494 lbs. fat and 3.55 percent. The inbred daughters were grouped in ranges of five percent and the results were as follows: 75 daughters averaged 3.50% F., 15,225 lbs. milk, 574 lbs. fat, 3.77 percent; 173 daughters averaged 8.70% F., 14,585 lbs. milk, 550 lbs. fat, 3.77 percent; 96 daughters averaged 13.38% F., 14,180 lbs. milk, 531 lbs. fat, 3.75 percent; 69 daughters averaged 18.59% F., 14,668 lbs. milk, 531 lbs. fat, 3.62 percent; 20 daughters averaged 24.27% F., 13,729 lbs. milk, 499 lbs. fat, 3.63 percent; 8 daughters averaged 29.08% F., 13,886 lbs. milk, 522 lbs. fat, 3.76 percent; 1 daughter with 41.41% F. produced 12,719 lbs. milk, 501 lbs. fat, 3.94 percent. The within sire regression on inbreeding was −33.1 lbs. of milk, −.77 lbs. of fat and +.0026 percent fat. These are smaller values than have previously been reported in studies of the effects of inbreeding. The within sire correlations are as follows: between inbreeding and milk and milk production, −.063; between inbreeding and fat production, −.036; between inbreeding and fat percentage, +.045. None of these correlations is significant.

THE HERITABILITY OF THE LENGTH OF THE ESTROUS CYCLE IN THE BOVINE. P. J. Dziuk, M. C. Hervey, A. L. Brundage and J. D. Donker, *University of Minnesota.*

The length of the period in days, from the onset of one estrous cycle to the onset of the following estrous cycle, was recorded for nine unselected sets of monozygotic twin virgin heifers of mixed grade breeding. There were from 3 to 10 observations for each individual with 106 total observations. Only those periods preceding the first breeding which were less than 25 and more than 14 days long were included in this study. Estrus was ascertained by willingness to stand while being mounted by other heifers of the twin herd. The animals were usually observed twice daily but occasionally only once when they were turned into an exercise lot. The mean length of the estrous cycle for all animals was 19.88 days with a standard deviation of 1.64 days. There was a significant difference between sets as compared to between members of sets using the F test (significant at approximately the 3% level). Heritability estimate for the length of the estrous cycle when measured in days as in this study was 61%. Behavior during estrus and intensity of demonstration was markedly similar in heifers of a set. Behavior toward other animals in heat, especially the twin mate, was also observed to be much alike within twin sets.

THE EFFECTS OF GENETIC DIVERSITY AND PERFORMANCE OF INBRED LINES *PER SE* ON HYBRID VIGOR IN SWINE. David C. England and L. M. Winters, *University of Minnesota.*

The performance records of 2332 crossbred pigs were analyzed in a study of the effect of genetic diversity on crossbred performance. The basis of comparison of crosses of various genetic widths was the relative superiority over parental averages. Performance was based on fertility, survival, weaning weight, and rate and economy of postweaning gain. Close agreement existed between increased genetic diversity and increased superiority of performance. Heterotic stimulus was greater for preweaning than for postweaning traits. A distinct effect on prenatal survival was indicated. Average single cross advantage (five factors) ranged from 5.40 percent for the least divergent group to 13.50 percent for the most divergent group; crisscrosses ranged from 9.53 to 14.78 percent. Average crisscross advantage was 13.03 percent versus 13.83 percent for rotation crosses. Widely divergent rotation crosses showed 4.5 percent more superiority than narrowly divergent rotation crosses. Backcrosses of two lines and single crosses of three lines exhibited 12.13 and 13.75 percent advantage respectively. All crossbreds showed less relative variation than inbreds. The advantage of three (or more) lines over two in continuous crossing appears to be in maintenance of greater genetic diversity rather than in providing a greater total of individually more favorable genes. With the effect of genetic diversity held constant, intercrossing of six inbred lines showed good agreement between performance *per se* and performance in crosses. Results indicate that the more effective gene combinations in the respective lines also contribute the more effective gene combinations in line crosses and thus strengthen the case for performance testing as the basis of selection.

SEMEN EVALUATION TECHNIQUES AND FERTILITY OF DAIRY BULLS. J. E. Johnston, C. Branton and F. Hathorn, *Louisiana Agricultural Experiment Station.*

Three hundred and fifty semen samples collected from 4 Jersey, 5 Holstein and 5 Guernsey bulls and used in breeding 15,029 first service cows were evaluated

and analyzed in order to determine the efficiency of a set of minimum standards of semen quality. The following standards were employed: Initial motility—at least 50%; Concentration of spermatozoa—500×10^6 or over; Methylene Blue Reduction time (Standardized)—9 minutes or less. Semen was diluted to contain 10×10^6 motile spermatozoa. A correlation analysis was utilized to determine whether any of the following semen characteristics were significantly related to 60–90 day non-returns: (1) Initial Motility; (2) % Live Spermatozoa; (3) % Live Spermatozoa after 0° C. Cold Shock; (4) % Abnormal Spermatozoa; (5) Concentration of Spermatozoa; (6) Methylene Blue Reduction Time. The only characteristics showing a significant relationship to fertility were (1) .12* and (2) .17**. From these results it would appear that minimum initial motility should have been slightly over 50%, otherwise the standards eliminated samples of predictably low fertility. The absence of any correlation between spermatozoa concentration and fertility (.01) was probably due to dilution on the basis of spermatozoa numbers.

HERITABILITY OF RATE OF GAIN FROM PROGENY TESTS WITH BEEF CATTLE. C. M. Kincaid, R. C. Carter and J. S. Copenhaver, *Virginia Agricultural Experiment Station.*

Direct estimates of heritability of growth rate in beef cattle were obtained through progeny tests of sires that had been individually fed on record of performance tests for at least 168 days after weaning at 6 to 9 months of age. Matings for progeny tests of equal numbers of paired fast and slow gaining sires have been made as follows: 2 pairs in 1948, 4 pairs in 1949, 5 pairs in 1950, 4 pairs in 1951 and 4 pairs in 1952. Numbers of bulls fed on record of performance tests from which selections were made and average daily gains of fast and slow gainers selected for progeny tests were: 8, 1.93 and 1.75 in 1948; 24, 2.09 and 1.45 in 1949; 30, 2.09 and 1.59 in 1950; 26, 2.46 and 1.58 in 1951; 41, 2.37 and 1.64 in 1952. To date, samples of steers from the first three of these matings have been full-fed on individual record of performance tests for at least 200 days while the heifers have been tested on pasture alone after limited feeding during their first winter. The steer progeny feeding tests included 15 in 1949–50, 30 in 1950–51 and 36 in 1951–52. Estimates of heritability of growth rate based on differences between fast and slow gaining pairs of sires and their steer progenies were 33, 42 and 0 percent, respectively. The heifer progenies with completed tests on pasture, 16 in 1950 and 39 in 1951, gave respective estimates of 0 and 20 percent. Average estimates of heritability of rate of gain weighted by numbers of pairs of sires progeny tested in each year were for the steers and heifers, 22 and 12 percent, respectively.

A STUDY OF THE USE OF INBRED BOARS FOR CROSSBREEDING IN SWINE. William R. King, J. L. Gobble, and W. L. Henning, *The Pennsylvania State College.*

The results of the second year of crossbreeding, using inbred boars, at the Pennsylvania Experiment Station have indicated some advantages for the crossbred pig, particularly in the feed lot trials. They were more vigorous than the pedigreed pigs during the nursing period, but it was not until weaning time that the better performance of the crossbreds became evident. They did not exhibit any significant advantage over the pedigreed pigs in the number of pigs farrowed per litter, percent farrowed alive per litter, and birth weight per pig. The number of pigs weaned per litter was slightly in favor of the crossbreds. The crossbred pigs were heavier at weaning time and again at 140 days. At each of these two weighing periods the pedigreed pigs were heavier in only one of all comparisons

possible. The crossbred pigs also made greater average daily gains than did the pedigreed pigs. They averaged 1.259 pounds per day or 0.092 pound more per day than the pedigreed pigs. The crossbreds did, however, show a definite economic advantage in the number of days required to reach market weight. They averaged 158 days to reach approximately 225 pounds as compared to 176 days for the pedigreed pigs.

A STUDY OF PROTEIN BOUND IODINE IN THE PREDICTION OF RATE OF GAIN IN IMMATURE BEEF CATTLE. H. O. Kunkel, R. W. Colby and C. M. Lyman, *Texas Agricultural Experiment Station.*

The serum protein bound iodine levels have been determined in a total of 54 beef calves, 8–11 months of age, in 3 feeding trials. These levels were compared to subsequent or concomitant feed lot gain. The results indicate that groups of Hereford and Aberdeen Angus calves which show a wide variation in protein bound iodine exhibited a wide variation in rate of gain. In 10 individually fed Hereford bulls, a high correlation between efficiency of gain and this iodine level was evident. Under certain conditions a negative correlation between the level of protein bound iodine and feed lot gain was observed. A study of a group of Aberdeen Angus and Hereford bulls indicates that this negative correlation exists only in animals which have an optimal or higher level of protein bound iodine. A low level may be accompanied by lowered rates of gain. It is suggested that the level of serum protein bound iodine may be used as an index of the potential efficiency of feed utilization in immature beef cattle.

COMPUTATION OF INBREEDING AND RELATIONSHIP COEFFICIENTS IN POPULATIONS WITH A RELATIVELY SMALL NUMBER OF DIFFERENT MALE ANCESTORS. Mogens Plum and H. P. Davis, *University of Nebraska.*

The computation of Wright's inbreeding and relationship coefficients involves the tracing of all the paths which connect two individuals through a common ancestor. Within a herd the number of male individuals appearing in the pedigrees is often limited to relatively few animals. When the number of different males appearing in the pedigrees is limited, inbreeding coefficients may be calculated readily from covariance charts involving the males only, and from pedigrees which need to be tracked back only through the female line of ancestry. An individual X has a dam A_o, maternal grandam A_1, maternal great-grandam A_2 and so on back along the female line to A_n. The mates to the different A-individuals are designated M_o, M_1, M_2, M_3 — — — — M_n. The inbreeding of X is then half of the genic covariance between A_o and M_o. But since cov A_oM_o equals cov $M_oM_1/2$+cov $M_oM_2/4$ — — — — — — — cov $M_oM_2/2^n$ any inbreeding coefficient may be computed from a covariance chart involving the males of the population. The method has one limitation. If one of the A-individuals is also an ancestor of one of the M-individuals, the formula cannot be applied back of the A-individual which is a common ancestor.

A STUDY OF SELECTION FOR FACTORS OF PERFORMANCE IN INBRED LINES OF POLAND CHINA SWINE. W. E. Rempel and L. M. Winters, *University of Minnesota.*

The records of performance of eight inbred lines of Poland China swine were subjected to a study of selection. The combined data consist of 1,178 litters farrowed, and 5,452 pigs raised to 154 days. The amount of selection was measured

by the average superiority of the animals chosen to be parents over the average of their generation. The average annual selection differentials were: (1) number of live pigs farrowed, .90 pig; (2) number of pigs weaned, 1.20 pigs; (3) conformation score, .69 point; (4) feed per hundred pounds of gain, —2.66 pounds; (5a) growth rate as measured by 154-day weight, 15.73 pounds, and (5b) growth rate as measured by daily gain from 56 days to 154 days, .13 pounds. Theoretical rates of annual change were computed from the selection differentials, the heritabilities of the characteristics and estimates of the effects of inbreeding. The actual rates of change were determined from the linear regressions of performance on time by using the annual means weighted by the number of records represented by each mean. The actual and theoretical rates of change were in good agreement both as to direction and size of the changes. The results of this study showed that the performance of the pigs in these inbred lines has been fairly well maintained by the use of a flexible system of inbreeding and selection, both of which are based on rigid performance testing.

GENETIC AND ENVIRONMENTAL FACTORS AFFECTING PREWEANING GROWTH OF HEREFORD CATTLE. W. C. Rollins, H. R. Guilbert and P. W. Gregory, *University of California.*

In a study of genetic and environmental factors affecting preweaning growth of purebred Herefords, the calf's rate of growth was analyzed for two periods, birth to 4 months and 4 months to 8 months. The estimated rate of growth of a calf for each period is a linear regression coefficient (pounds gain/day) based on 5 monthly weighings. The rate of growth from birth to 4 months is designated as b_1, and that from 4 months to 8 months as b_2. Adjustment of the data for sex, age of dam, season and year of birth reduced the variance of individual rates of gain approximately 41% for b_1 and 61% for b_2. A variance and covariance analysis of b_1 and b_2 suggests the following hypothesis: The growth mechanism and the genetic factors affecting it for the period birth to 4 months are significantly different and independent of the mechanism and genetic factors operating for the period 4 months to weaning. A possible explanation for this may be that the principal variation in genotype for rate of growth for the period birth to 4 months may be concerned with the calf's vigor and adaptability to postnatal conditions; while for the period 4 months to 8 months, genotypic differences for ultimate size and rate of maturity may be the principal source of genetic variation in rate of growth. A repeatability of 37% (for b_1) and 26% (for b_2) for the rate of growth of a cow's calf was estimated.

PRODUCTION CHARACTERISTICS OF CROSSBRED, BACKCROSS, AND PUREBRED RED SINDHI CATTLE IN THE GANGETIC PLAINS REGION. H. H. Stonaker, O. P. Agarwala, and D. Sundaresan, *Colorado A & M College.*

In the herd of crossbred Jersey x Sindhi, Sindhi backcrosses and purebred Red Sindhi of the Allahabad Agricultural Institute, Allahabad, India, dairy performance as related to breeding has been studied. In percentage of butterfat in the milk the crosses showed slight but non-significant increases over the purebred Sindhis; also differences in the length of calving intervals or in survivability of young calves for the different groups were not significant. Large differences appeared between the groups in ages at first calving and in the production of butterfat in lactation periods of 305 days. Age at first calving tended to decrease as relationship to the Jersey increased. Crossbred Jersey-Red Sindhi heifers calved 12 months younger than Red Sindhis, and ¾ Jersey-¼ Sindhi heifers calved 16 months younger than purebred Red Sindhis. In butterfat pro-

duced in 305 day first lactation records, crossbred Jersey-Red Sindhis gave 68 pounds butterfat (47 percent) more butterfat than purebred Red Sindhis. Of the cows having first lactations, over twice the proportion of crossbred cows have remained in the herd for a period of six lactations as purebred Red Sindhis. It appeared as a result of this study that the production of all proportions of Jersey breeding used exceeded the production of the Red Sindhi, with the amounts decreasing as relationship to either Jersey or Red Sindhi deviated from 50 percent.

BLOOD TYPING AS A MEANS OF DIFFERENTIATING THE POTENTIALLY FERTILE FROM THE NON-FERTILE HEIFER BORN TWIN WITH A BULL. William Stone, C. Stormont and M. R. Irwin, *University of Wisconsin.*

The explanation underlying the differentiation of the fertile from the non-fertile heifer born twin with a bull is based upon the assumption that the fusion of embryonal vascular tissue which occurs frequently among twins provides a bridge across which the cells ancestral to the tissues which form the erythrocytes can migrate reciprocally from one twin to the other. The heifer in a pair of unlike-sexed twins which had communal circulation during prenatal life shows an admixture of bloods composed of two distinct cell-types, one derived from her own hemopoietic tissues and the other from the tissues of her co-twin. All heifers with a blood admixture are presumed to be sterile. In contrast, the twin heifer which had no communal circulation during embryonic life will show no admixture and should be as fertile as if born singly. Within recent years, more than 74 pairs of unlike-sexed twins have been tested and as expected the majority had blood admixtures and were predicted to be sterile. Of those with admixtures, only 12 heifers were examined post mortem and showed varying degrees of abnormalities of the reproductive organs. However, there were eight heifers which showed no blood admixture and were predicted to be potentially fertile. Each of these heifers has had a calf or has become pregnant. These results show that the blood typing test in cattle is a highly precise method of differentiating the potentially fertile from the non-fertile heifer in twins of unlike sex.

THE EFFECT OF SELECTION ON THE INCIDENCE AND HERITABILITY OF NECK FOLDS IN RAMBOUILLET WEANLING LAMBS. Clair E. Terrill and W. H. Kyle, *U. S. Sheep Experiment Station and Western Sheep Breeding Laboratory.*

Scores for neck folds on Rambouillet weanling lambs were studied on 5,083 ram lambs and 5,619 ewe lambs born from 1938 through 1951 in one-sire inbred lines. Intense selection against skin folds was practiced during most of these years. Neck folds were scored as follows: "1" no folds, "2" very few folds of small or moderate size, "3" folds of moderate number or size, "4" heavy folds of moderate or large number, and "5" completely covered with heavy or large folds. Average scores decreased from 2.41 in 1938 to 1.13 in 1948 for rams and from 2.29 in 1938 to 1.06 in 1950 for ewes. Rams had higher scores than ewes in every year. Heritabilities were estimated within sexes and years from half-sib correlations in all years and from intra-sire regressions of offspring on dam for the years 1943 through 1951. There was no consistent sex difference in heritability. Heritabilities from half-sib correlations were generally high in the years from 1938 to 1943 ranging from 0.30 to 1.15 for rams and from 0.43 to 0.81 for ewes. These estimates decreased to 0.09 for rams and 0.08 for ewes in 1946. There were some fluctuations from 1946 to 1951 but all estimates were low with

one exception. Lowest estimates of heritability were 0.05 for rams in 1951 and 0.04 for ewes in 1948. Heritabilities from offspring-dam regressions were higher than those from half-sib correlations after 1943, and ranged from 0.18 to 0.63 for rams and from 0.18 to 0.51 for ewes.

CROSSBREEDING EFFECTS ON GROWTH, DIGESTION, FEED UTILIZATION AND CARCASS COMPOSITION IN SWINE UNDER FULL AND EQUALIZED FEEDING, WITH AND WITHOUT ANTIBIOTIC. H. F. Tucker, G. E. Dickerson and J. F. Lasley, *University of Missouri.*

Crosses of Landrace with Durocs, Poland Chinas and Hampshires, and these four purebred stocks, were full-fed from weaning to market weight. One of two lots of 8 pigs from each cross or strain received procaine penicillin (2 mg./lb. of feed). Feed intakes of two other lots from each of these crosses, and from the Poland-Duroc cross, were limited to those of the parental full-fed lots, one receiving antibiotic. Under full-feeding, crosses gained 7 percent faster and reached final weight 10 days earlier, but consumed 6 percent more feed daily and were no more efficient than the parental purebreds. Two 5-day trials using chromium oxide indicator technique, disclosed no differences in efficiency of digestion. Crosses yielded slightly less lean but more fat and belly and nearly the same loin equivalent. Under equalized feeding, crosses consumed 2 percent more feed daily, but gained 12 percent faster and 6 percent more efficiently than parental purebreds, with no difference in efficiency of digestion. Crosses were marketed 14 days earlier and dressed 1.4 percent less; but adjusted loin equivalent was only .7 percent lower. Carcasses from crosses, particularly when limited-fed, were slightly longer in body and leg, with thinner fat and bellies, higher scores of cuts and smaller gross area of lean in ham and loin cross-section. Continuous antibiotic feeding influenced none of the characters studied, probably because all lots received aureomycin during a severe reaction to cholera immunization early in the experiment.

AN OPTIMUM WEIGHTING OF COMPONENTS OF PERFORMANCE IN SELECTING FOR HETEROSIS IN SWINE. William M. Warren and Gordon E. Dickerson, *University of Missouri.*

Performance data for 807 linecross pigs from reciprocal matings of two inbred Poland tester lines with nine strains of five breeds during two seasons were analyzed in an attempt to determine the optimum emphasis to be placed on prolificacy (X), rate of gain (Y), feed requirements (W), and carcass merit (Z) of the linecross progeny in evaluating the nine parental lines. The method of fitting constants was used to remove bias from the disproportionate representation of the tester and season influences on crosses of the nine lines. The four traits were combined into an index (I) to evaluate the net cross-performance of the nine lines with maximum accuracy: $I = +.21X + 5.0Y - .027W + .51Z$. Line differences in the index were highly significant. The lines ranked: Iowa Landrace, Outbred Duroc, Beltsville Landrace, Yorkshire, Iowa Poland, V Hampshire, Outbred Hampshire, Outbred Poland, and T-Duroc. The range among line means represented 2.9 percent of the average gross returns per cwt. marketed. Similar indexes for use in selecting among individual sires (I_s) and dams (I_d), based on the performance of their linecross progeny were $I_s = +.19X + 3.3Y - .020W + .36Z$; $I_d = +.07X + 2.9Y - .009W + .23Z$. A 20 percent limitation in feed consumption in the fall season reduced feed required per 100 pounds gained by 19 pounds, backfat thickness by 2.12 mm., and net carcass merit by only 0.49

percent. The net advantage of limited feeding was greatest for those crosses which were inherently fatter at market weight.

HERITABILITY OF FUR CHARACTERS AND BIRTH WEIGHT IN KARAKUL LAMBS. T. S. Yao, V. L. Simmons and R. G. Schott, *U. S. Department of Agriculture.*

Heritability estimates for eight fur characters and for birth weight were calculated from 728 purebred and grade Karakul lambs and their 207 dams and 22 sires raised at the Agricultural Research Center, Beltsville, Maryland, from 1942 through 1949. The estimates were also computed for these characters separately in the purebred and three grade groups—Karakul x Black-faced Highland, Karakul x Corriedale, Karakul x Navajo. Three methods—paternal half-sib correlation, intra-sire regression on dam, and mid-parent regression, were used in the estimation. The variances for lambs, dams and mid-parents and the covariances between lambs and dams, lambs and mid-parents were corrected with the variances and covariances caused by breed, year and sire differences, and "year x sire" interactions. The percent heritability estimates for the nine characters were: (1=half-sib correlation method, 2=intra-sire regression method, 3=mid-parent regression method) Curl size (1)29–59% (2)32–67% (3)30–54%; tightness (1)13–67% (2)24–72% (3)16–68%; luster (1)44–77% (2)12–75% (3)5–81%; desirability (1)12–17% (2)6–31% (3)10%; curl type (1)25%; pattern (1)2% (2)10%; texture (1)13%; hair length (1)9%; birth weight (1)6–51% (2)17–63% (3)25%. Curl size, tightness and luster were regarded as of high heritability; desirability, curl type and birth weight of medium heritability; pattern, texture and hair length of low heritability. The mid-parent regression method in most cases gave more consistent estimates in the different classifications and thus seems to be the preferable one for heritability estimates in this material.

Extension Section

H. G. Zavoral, *Chairman*

PRODUCTION INDEXING OF SHEEP ON WISCONSIN FARMS. V. L. Felts, A. L. Pope, and A. B. Chapman, *University of Wisconsin.*

The Wisconsin Sheep Improvement Program was started in 1949 as an organization to help the farmer keep accurate records and to provide him with a selection index for improving his sheep in economically important characters. This is done by a simple and efficient method of keeping the necessary records, making adjustments for age and type of birth, weighing the lambs and calculating a production index on each ewe and lamb in a flock. The characteristics included in the indexes are body weight at 4 months of age, fleece weight, and twinning ability. It is planned that this program will serve as the main channel for extension work in sheep husbandry through direct contacts with the cooperators and by use of periodic printed material. It also provides an opportunity for ascertaining the major problems confronting the producers and supplies data for research work on selection and mating systems.

Meats Section

R. W. Bray, *Chairman*

THE INFLUENCE OF AGE OF HOGS ON THE HAM CURING PROCESS. T. N. Blumer, F. H. Smith, H. L. Lucas and W. E. Tyler, *North Carolina State College.*

Thirty-six hogs of similar breeding and similar ages were fed alike for a twelve month period. Four hogs were selected at random each month and slaughtered beginning when the hogs were four months of age and continuing through the twelfth month. The effect of age of the hog on the curing processes was determined. The left hams were used for the determination of chemical analyses whereas the right hams were dry cured with salt. The cured hams were sampled at the time they were removed from cure and each two weeks thereafter until salt equalization was attained. The salt absorbed per pound of ham was essentially independent of the size of ham and age of the hog. There was a significant negative correlation, however, between the salt absorbed per pound of ham and fatness of the ham. For all practical purposes the salt per 100 grams of moisture equalized throughout the ham in sixteen to twenty-four weeks. The rate at which the salt equalized was conditioned by weight of ham, fat content of the ham and salt absorbed. Age of hog had no demonstrable effect on rate of salt equalization over and above the effect of the weight of ham. The time trends in salt per 100 grams of moisture in different parts of the ham, and the effects of weight of ham, fatness of ham and salt absorbed on these trends are shown by graphs.

EXPLORATORY STUDIES ON THE PROCESSING OF FRESH BEEF BY THE INFUSION OF ANTIBIOTICS. V. R. Cahill, L. E. Kunkle, Herbert Goldberg, H. H. Weiser and F. E. Deatherage, *The Ohio Agricultural Experiment Station and The Ohio State University.*

Experiments were conducted to determine if the infusion of antibiotics could retard deep spoilage in meat. Following screening experiments, aureomycin, chloromycetin and terramycin showed promise for processing meat. For these studies aureomycin was used. More than twenty animals were used in individual experiments. Following slaughter the rounds were immediately removed from the carcass. One round was kept as a control and the other was infused with aureomycin dissolved in saline. Both rounds were at room temperature 70–80° F. from 24–72 hours. At the conclusion of the holding period the rounds were cut down and examined for spoilage. Bacterial counts were taken in the muscle and in the lymph nodes. Although there were a number of sour rounds in the controls none of the infused rounds spoiled. Antibiotic residues were also determined. Processing of meat in this fashion may be particularly applicable to improving tenderness or for handling meat where there is limited or no refrigeration. These studies are being continued.

THE EFFECT OF VARIOUS GRADES AND LENGTHS OF PORK CARCASSES TOGETHER WITH SEX ON THE YIELD OF SLICED BACON. J. W. Cole, C. E. Riley, and C. S. Hobbs, *University of Tennessee.*

In this study 364 pork carcasses were selected on a rail basis in the cooler and were representative of the kinds of hogs produced in the East Tennessee Area. These carcasses were graded according to the proposed standards set up by the Production Marketing Administration of the United States Department of

Agriculture. Of the 364 hog carcasses used 45 percent graded choice #1, 26 percent graded choice #2, 4 percent graded choice #3, and 25 percent graded medium. The usual procedures were used in cutting, trimming, curing and smoking the green bellies. Each side of bacon was sliced and graded into the various grades of sliced bacon namely, #1, #2, #3, and bacon ends. In this study it was found that the medium grade carcasses yielded 51.33 percent of number one grade of sliced bacon as compared with 45.85 percent for choice #1, 40.36 percent for choice #2, and 32.67 percent for choice #3. A monetary value was given to the sliced bacon produced by the various carcass grades. The sliced bacon from medium grade carcasses had the highest monetary value per hundred pounds of green belly weight, while the sliced bacon from choice #3 carcasses had the lowest. The mean percent of waste and shrink was lowest from the bellies produced from the medium grade carcasses. The data show that sex has no significant effect upon the yield of sliced bacon. Likewise there seems to be no definite trend concerning the effect of length of carcass within the grades upon the yield of bacon.

A REVALUATION OF THE SIGNIFICANCE OF DRESSING PERCENTAGE OF HOGS. O. G. Hankins, R. L. Hiner, and H. S. Sloane, *U. S. Department of Agriculture.*

Fat hogs as a rule "dress" higher than thin hogs of similar weight. Moreover, there are good indications that with increase in fatness in a given case there is an increase in dressing percentage. Nevertheless observations at Beltsville, Maryland, in recent years in research on the development of meat type hogs suggested that fatness is not necessarily the most important factor affecting dressing percentage. For this study, selection was made of 41 animals that varied widely in breeding, type, fatness, meatiness, prospective dressing percentage and other characteristics. Feeding and management, however, were uniform and final feedlot weight varied little. To avoid the variable associated with "fill," dressing percentage was determined on the basis of empty body weight (live weight minus weight of contents of digestive tract) and chilled carcass weight. The range was from 79.67 to 85.53 percent with a mean of 82.56. The correlation between thickness of back fat, known to be a good index of total fat content, and dressing percentage was +0.43. When the combined yield of fat cuts including back fat, leaf, plate and trimmings was used as another index of fatness and correlated with dressing percentage the coefficient was +0.42. At a given degree of fatness the dressing percentage varied as much as 4 percent. A closer relation between the combined yield of preferred cuts, including hams, loins, bacons, picnics and butts, and dressing percentage, was shown by the correlation coefficient of +0.55. This finding together with further analysis of the data indicated that muscular development was a major factor influencing dressing percentage among these hogs.

GROWTH AND CARCASS CHARACTERISTICS OF PIGS FED ANTIBIOTICS FOR PART OR ALL OF THE GROWING FATTENING PERIOD. L. E. Hanson, E. F. Ferrin, P. A. Anderson, and W. J. Aunan, *University of Minnesota.*

In one experiment last year and one in 1952, 152 pigs were fed in paved lots to study the adequacy of the basal ration in vitamin B_{12} and to compare the relative merits of aureomycin, procaine penicillin and terramycin supplements when fed from weaning until the pigs reached 125 lbs. in weight, and when fed from weaning to market weight. The basal mixture was composed of

ground yellow corn, supplemented with a mixture of 46% soybean meal, 20% tankage, 10% linseed meal, 20% dehydrated alfalfa meal, 2% steamed bone meal and 2% iodized salt. Sufficient supplement was fed to make an 18% protein ration from weaning to an average weight of 125 lbs. and a 15% protein ration thereafter. Vitamin B_{12} was added at a rate of 10 mg. per ton of feed for lots 2–8 inclusive; lot 1 served as a control. In addition the following antibiotics were fed: Lot 3, aureomycin to 125 lbs.; Lot 4, aureomycin to 200 lbs.; Lot 5, terramycin to 125 lbs.; Lot 6, terramycin to 200 lbs.; Lot 7, procaine penicillin to 125 lbs.; Lot 8, procaine penicillin to 200 lbs. The antibiotics were fed at a level of 10 grams per ton of feed. The daily rate of gain and feed required per 100 lbs. of gain for the first experiment was as follows: Lot 1, 1.21–352; Lot 2, 1.40–340; Lot 3, 1.53–350; Lot 4, 1.63–349; Lot 5, 1.46–350; Lot 6, 1.57–326; Lot 7, 1.45–335; Lot 8, 1.54–332. The present experiment has produced similar results to date. Only three pigs per treatment were slaughtered in the first experiment, but all of them will be slaughtered in the second experiment.

THE EFFECT OF DELAYED CHILLING ON THE PRESERVATION AND QUALITY OF CURED PORK. Marshall C. Heck and E. S. Ruby, *University of Arkansas.*

The study was conducted to provide information and data on the effect of delayed chilling of pork carcasses following slaughtering and to determine the effect of salt and sugar cures on hams and shoulders of these carcasses. Ten hogs weighing 170 to 243 pounds were used for this study. The chilled carcasses averaged 152.8 pounds. The hams had an average weight of 13 pounds. The average weight of the shoulders was 11.5 pounds. Five judges scored the hams and shoulders for aroma, flavor of lean, flavor of fat, texture and tenderness. When the chilling of pork carcasses is delayed for as much as four hours following slaughter the aroma of the cured meat is definitely less desirable. The aroma of hams is not affected as much as is shoulders. Flavor of lean is greatly affected by delaying the chill. Delaying the chill did not lower the juciness of the cuts. Delaying chilling did cause the skin to dry and become hard. Juciness in cured meat was difficult to score by the judges. Where all factors were concerned, higher quality cured meat is obtained by chilling the pork carcasses as soon after slaughtering as possible. When the chilling is delayed lower quality cured hams and shoulders may be expected. The information obtained is of value in determining a cause for off flavors of cured hams and shoulders.

FIBER DIAMETER IN RELATION TO TENDERNESS OF BEEF MUSCLE. R. L. Hiner, O. G. Hankins, H. S. Sloane, C. R. Fellers, and E. E. Anderson, *U. S. Department of Agriculture and University of Massachusetts.*

Studies were made to determine the relationship of resistance to shear (tenderness) and diameter of fiber in beef muscles that varied widely in tenderness. Nine samples of muscle were used from each of 52 beef animals that varied from ten-week-old calves to nine-year-old cows. The carcasses were aged approximately 14 days at 0.6° to 1.7° C. (33° to 35° F.), cut into their primal cuts, and from these the nine samples each 1.5 inches thick were removed. After removing histological sections, the samples were weighed, heated to an internal temperature of 60° C. (140° F.) in an electric oven at 200° C. (392° F.), and tested objectively for tenderness. The histological sections were fixed in 10 percent formalin solution for five to eight days. From these fixed samples muscle fibers were teased out and measured. The muscle samples classified

themselves according to increasing average diameter of fiber into four general groups as follows: (1) tenderloin; (2) the two chuck samples, eighth rib, short-loin and loin end; (3) round; (4) neck and foreshank. With increasing age of animal there was a consistent increase in average muscle fiber diameter for all samples studied. Coefficients of correlation of resistance to shear (tenderness) and diameter of fiber ranged from +0.75 for the neck sample to +0.31 for the foreshank. The relationship between tenderness and fiber diameter for all of the samples was curvilinear with a $\overline{p}$ of .83. All correlations involving samples from any one age group were very highly significant. They varied from +0.50 for veal calves to +0.77 for mature cows.

THE ECONOMY AND NUTRITIVE VALUE OF DIFFERENT CUTS OF LAMB OF DIFFERENT GRADES. James D. Kemp, Sleeter Bull, and H. W. Bean, *University of Illinois.*

Quantitative data were determined regarding the physical and chemical composition, energy values, and economy of the carcasses and retail cuts of 11 Prime, 13 Choice, 11 Good, and 11 Utility lamb carcasses from Western, black-face, wether lambs of similar breeding and size. Nomographic charts show the economy of cuts based upon the percentages of fat, protein, and edible meat. The percentages of leg, shoulder, neck, foreleg, and kidney increase, but the dressing percentage, and the percentages of loin, rack, breast and flank, and kidney fat decrease with a decrease in grade. The percentages of edible meat and fat decrease, but the percentages of lean and bone increase with a decrease in grade. Grade has no significant effect upon the percentages of protein in fresh lean; however the percentage of protein increases with a decrease in grade in dry lean, fresh and dry fat, and fresh and dry edible meat. The percentage of ether extract decreases with a decrease in grade in fresh and dry fat, fresh and dry edible meat, and fresh cut but not always in fresh and dry lean. The percentage of dry matter in lean, fat, and edible meat decreases with a decrease in grade. At the same price per pound of the same cut, lower grade cuts are more economical when purchased on a lean basis, similar in economy when purchased on a protein basis, and usually less economical when purchased on an edible meat basis.

THE INFLUENCE OF FEEDING VITAMIN B_{12}, COBALT AND ANTIBIOTICS ON THE COMPOSITION OF PORK TISSUE. E. A. Kline, J. Kastelic, L. Y. Quinn, P. G. Homeyer and D. V. Catron, *Iowa State College.*

Twenty-four weanling pigs were individually fed vitamin B_{12} deficient and cobalt low semi-purified rations. Litter mates were randomly allotted, one to each of four ration treatments: basal; vitamin B_{12}; cobalt; and vitamin B_{12}+cobalt. One-half of the animals received a mixture of 100 mg. each of aureomycin, terramycin, streptomycin, penicillin and sulfathalidine per lb. of ration. Analyses for B_{12}, Co., P, N, fat and water were made. Standard plate counts were conducted on feces from these animals. Excellent average daily gains and feed efficiencies were obtained. Nutritional deficiencies were not observed on any ration. Cobalt additions (3 P.P.M. of ration) did not improve growth of any of the animals. Feeding of B_{12} to non-antibiotic fed animals increased gains in the absence of cobalt, but in the presence of cobalt gains were depressed. B_{12} and cobalt had no influence on rate of gain, feed consumption or feed efficiency when antibiotics were also fed. Increased cobalt content was found in the livers of all animals fed the cobalt rations. The microbiological activity values for the B_{12} concentrations in liver, spleen and kidney were lower when cobalt was fed. The

data for muscle tissue revealed no differences. The B_{12} concentrations were highest in tissues from all animals receiving the vitamin. The phosphorus levels were significantly increased in all tissues by B_{12} feeding when cobalt and the antibiotics were omitted from the rations. These differences disappeared when antibiotics were present in the ration. Differences in the nitrogen, fat and water content of tissues and in the specific gravity of the carcasses were not significant. The trends of the bacteriological studies revealed that cobalt decreased the fungi and increased the coliform fecal counts. Antibiotic feedings resulted in marked increase in both fungi and total counts.

THE EFFECT OF STILBESTROL ON CERTAIN CARCASS CHARACTERISTICS AND FEED UTILIZATION OF FULL-FED AND LIMITED-FED WESTERN LAMBS. C. C. O'Mary, W. S. Wilkinson, G. D. Wilson, R. W. Bray, A. L. Pope and L. E. Casida, *University of Wisconsin.*

A group of 20 wether lambs were placed in each of the following: (1) treated, full-fed (2) control, full-fed (3) treated, limited-fed to gain as group 2 (4) control, same feed as 3. These lambs were slaughtered at 49 days. The same 4 treatments were also duplicated and slaughtered at 84 days. In addition a full-fed group implanted in the ear instead of the neck was slaughtered at 49 days. The carcasses of full-fed treated animals were larger at 49 and 84 days than their respective controls. Carcass weights of the ear and the neck treated animals were not significantly different. The dressing percentage was consistently lower in treated than in control animals. There was more bone, less external fat, more water in the fat, but no difference in the muscle between the treated and control animals at 49 days. At 84 days there was no difference in bone, thickness of external fat, or muscle between treated and control full-fed animals. However, there was less external fat in the limited fed treated than in the limited fed control animals. Digestibility studies were made using the 49-day groups to determine whether the greater "efficiency," previously demonstrated, was due to increased digestibility. The digestion coefficients using the chromic oxide ratio technique indicate no differences between treated and control animals in digestibility of either dry matter or protein of the ration.

LOSSES OF B-COMPLEX VITAMINS IN DRIP OBTAINED UPON DEFROSTING FROZEN PORK. A. M. Pearson, R. B. Sleeth, D. H. Kropf, M. A. Guess and F. H. Jack, *University of Florida.*

The Longissmus dorsi muscle was removed from the loins of two pork carcasses, cut into chops, packaged, frozen and stored at 0° F. Drip was collected by thawing the chops overnight at room temperature. The drip was then measured and analyzed microbiologically for certain members of the vitamin B-complex. In order to determine the levels of each vitamin in the meat before thawing, a sample of frozen tissue was removed from an adjacent chop and analyzed. The percentage of each vitamin lost in the drip was calculated. The meat contained 62.25 gammas of niacin per gram; whereas, the drip contained 83.00 gammas per milliliter, amounting to a loss of 9.78 percent of the total niacin in the meat. The riboflavin content of the meat was 1.03 gammas per gram, while the drip contained 0.52 gammas per milliliter, making a total loss of 5.81 percent in the drip. The vitamin B_{12} content of the meat was 1.51 gammas per 100 grams compared to 4.30 gammas per 100 milliliters for the drip, resulting in a loss of 32.97 percent of the vitamin B_{12}. The results of this study indicate that considerable quantities of the B-complex vitamins are lost in the drip obtained on defrosting frozen pork.

THE INFLUENCE OF VARIOUS FACTORS ON THE YIELDS OF PORK CUTS. W. L. Robison, L. E. Kunkle and V. R. Cahill, *Ohio Agricultural Experiment Station.*

The effects of weight, grain fed, rapidity of gains, level of protein, a B_{12} and antibiotic supplement, length, thickness of back fat, type and breed on the yields of pork cuts were studied. As weight increased the percentage of lean to total cuts decreased and the percentage of fat trimmings to total cuts increased. The lean cuts represented 51.9 and 48.3, and the fat trimmings 25.4 and 30.5 percent of the total cuts of 190 and 250 pound hogs, respectively. Carcasses from hogs fed oats contained a higher percentage of lean cuts and a lower percentage of fat trimmings than those from hogs fed corn, barley or hulled oats, which differed little in these respects. Carcasses from self and limited fed hogs from a pasture experiment contained 49.6 and 55.4 percent of lean cuts and 25.7 and 20.8 percent of fat trimmings, respectively. Carcasses from hogs fed rations containing 10, 12, 15, and 20 percent of protein yielded 46.5, 48.8, 51.4, and 56.1 percent of lean cuts, and 28.0, 26.7, 24.1, and 19.7 percent of fat trimmings, respectively. Carcasses from hogs on rations without and with a B_{12} and antibiotic supplement contained 51.6 and 49.9 percent of lean cuts and 23.6 and 24.8 percent of fat trimmings, respectively. As length increased and as back fat thickness decreased the percentage of lean cuts increased and the percentage of fat trimmings decreased. Hogs with low and hogs with high cut out values were found in each of the breeds studied.

RESIDUAL ARSENIC IN SWINE TISSUES FOLLOWING ORAL ADMINISTRATION. S. F. Scheidy, P. W. Wilcox and Alan A. Creamer, *Sharpe & Dohme, Inc.*

Sulfathalidine(R) phthalylsulfathiazole and arsenic in the form of sodium arsanilate was administered in wet mash for a period of one week, in two dosage levels, to young male and female swine weighing from 40 to 90 pounds. The dosage schedule followed was Sulfathalidine 65 mg. and arsenic 1.7 mg. per pound of body weight per day to six animals and twice these amounts to six other animals for a period of one week. Two animals from each group and an untreated control were destroyed three and eight days after last dose of the drugs. The following tissues were tested for arsenic content: stomach, small and large intestines, blood, fat, muscle, bone, heart, liver, kidney, pancreas, bile, spleen, skin, bristle and hoof. The Gutzeit test method was employed. The concentrations of arsenic expressed as arsenic trioxide in tissues from treated animals ranged from 0.01 to 5.3 parts per million.

USE OF INEDIBLE ANIMAL FATS IN RATIONS FOR DOGS. A. J. Siedler and B. S. Schweigert, *American Meat Institute Foundation and University of Chicago.*

Because of increased interest in developing new uses for inedible animal fats, studies on the value of adding animal fats to dry dog foods and poultry rations are particularly timely. The studies reported here are on the performance of dogs fed graded levels of inedible animal fat stabilized with antioxidants in addition to a ration composed of ingredients commonly used in dry dog foods. Weanling Cocker Spaniel pups were fed a dry meal (basal) to which 0, 4, 6 or 8% stabilized choice, white grease had been added at the expense of the ration. The results obtained for a 10-week experimental period show that the rates of gain of the pups fed 4, 6 or 8% fat were equal to or slightly superior to those for pups fed the basal ration. Results of interpretive experiments on

controlled food intakes and feed and caloric utilization are in accord with this conclusion. Female dogs from the second experiment have been continued on experiment. Results on the effect of adding graded levels of fat on the performance of these dogs for maintenance, reproduction and lactation will be presented. Other studies have also been conducted to determine the stability of vitamin A (added as fish liver oil) when no fat or 6% stabilized grease was added to the ration. During the first few months' storage of the feeds at room temperature, no marked differences in the vitamin A stability were evident. After 6 months' storage, a significantly greater stability of vitamin A was observed in the feeds to which stabilized fat was added.

A FURTHER INVESTIGATION OF SPECIFIC GRAVITY AS A MEASURE OF PORK CARCASS VALUE. Joe V. Whiteman, J. C. Hillier and J. A. Whatley, Jr., *Oklahoma Agricultural Experiment Station.*

The right hams from 23 carcasses were used to study the relationship among the parts of the hams and their respective specific gravities. Carcasses from 203 hogs were used to compare the associations between specific gravity and average back fat thickness and other measures of pork carcass leanness. A multiple correlation coefficient of 0.912 was found between the percentages of moisture, protein and ether extract and the specific gravity of the lean of the ham. Simple correlation coefficients of 0.949 and 0.942 between the specific gravities of the right untrimmed hams and the specific gravities of the respective half carcasses on two groups of carcasses indicate the high relationship that exists between the proportions of fat, lean, and bone of the half carcass and the proportions of the same constituents of untrimmed ham. Both the percentages and the densities of the fat and lean were more closely associated with the specific gravity of the untrimmed hams than was either the percentage or the density of the bone. The temperature of the meat at the time of weighing in water may be a source of error in the use of specific gravity, however, it is thought that the amount of error is too small to be of great practical importance if the carcass temperature range is from 30° F. to 36° F. A study of correlation coefficients indicated that specific gravity was more closely associated with the percentage of the lean cuts and with other measures of carcass leanness than was average back fat thickness.

PORK CARCASS VALUE AS AFFECTED BY PROTEIN LEVEL AND SUPPLEMENTATION WITH AUREOMYCIN AND VITAMIN B_{12}. G. D. Wilson, J. E. Burnside, R. H. Grummer and R. W. Bray, *University of Wisconsin.*

Ninety-six feeder pigs, averaging 45 pounds, were randomly allotted according to sex and weight into 12 lots. Four of these lots were fed a high protein ration, four an intermediate level of protein, and the remaining four a low protein ration. Within each protein level one lot served as a control, one was supplemented with vitamin B_{12}, one with aureomycin, and one with both aureomycin and vitamin B_{12}. As the lots averaged 213 pounds the hogs were slaughtered and the carcasses evaluated. The pigs receiving the high protein rations produced carcasses with a higher percentage of lean cuts than did either of the lower protein rations. Within the high protein lots there was little effect on the carcass value when the rations were supplemented. Within the two lower protein levels the addition of B_{12}, aureomycin, or a combination of the two, significantly increased the percentage of lean cuts. Aureomycin and B_{12} in combination produced the highest percentage of lean in the medium protein groups. There was not a significant difference between this lot and the high protein control lot. In general, the analysis of individual cuts showed the same effects of treatment as described for

the percentage of lean cuts. There were no significant differences in dressing percentage, length of carcass or fat back thickness between lots within each protein level.

Nutrition Section

W. D. Gallup, *Chairman*

SODIUM VERUS CHLORIDE FOR THE THERAPY OF SALT-DEFICIENT DAIRY COWS. Philip D. Aines and Sedgwick E. Smith, *New York State College of Agriculture.*

Studies were undertaken to characterize signs of salt deficiency in dairy cows on a natural ration and to determine the approximate requirement for salt of these animals. Thirty animals were fed a ration consisting of timothy hay, corn silage, and a concentrate mixture of corn, oats, wheat bran, linseed meal, and bone meal, without supplemental salt, or with 15, 60 or 120 gms. per day. The unsupplemented cows showed the following gross symptoms: depraved appetite, anorexia, loss in milk production, loss in weight, and occasionally such neuro-muscular signs as shivering and irregular heart action. Postmortem examination revealed hypertrophy and hyperplasia of the adrenal glands. An investigation was made to determine the relative importance of sodium and chloride ions in repressing these symptoms. When sodium chloride was fed to deficient cows, milk production rose 164 percent and body weight increased 24 percent during treatment. Increases in the sodium and chloride contents of the blood plasma were also noted. When sodium bicarbonate was fed, milk production increased 66 percent and body weight 18 percent. However, feeding magnesium chloride failed to interrupt a progressive decline in milk production and body weight. When sodium bicarbonate and magnesium chloride were fed together, milk production increased 90 percent and body weight 15 percent. These responses were supported by increased concentrations of sodium and/or chloride in the blood plasma. These results indicate that, under the conditions of this experiment, salt deficiency in lactating dairy cows is primarily due to an inadequacy of sodium.

VARIATIONS IN THE BUFFERING CAPACITY OF RUMEN JUICES AS AFFECTED BY THE RATION. Clarence B. Ammerman and W. E. Thomas, *University of Kentucky.*

Ruminal fistulated wether lambs were used for in vivo studies of the buffering capacity and pH values of rumen ingesta. Ladino, alfalfa and bluegrass forages were fed as hay and also grazed as pasture. Quantities of ruminal juices were obtained for buffering by expressing the ingesta removed from the rumen. There appeared to be definite differences in the buffering capacity of ingesta from different lambs regardless of which forage was consumed. Plant juices were extracted and treated so that their buffer capacity might be compared with that of the ingesta. Juices of bluegrass were more highly buffered than were the juices from Ladino and alfalfa. Also, the juices from mature Ladino and alfalfa appeared to be more highly buffered than the juices from these forages when young and succulent. Ruminal pH readings were made at two-hour intervals

through the day on the different forages to obtain a pH curve. Alfalfa and Ladino ingesta showed very similar pH values of about 6.70 when the lambs were fed hay. When the lambs were grazing alfalfa or Ladino pasture, the ingesta pH readings averaged 6.25 and 6.23 respectively. The bluegrass ingesta had a pH average of 6.90 when hay was fed and 6.56 when grazed. It is noted that all three forages produced a lower ruminal pH when grazed.

SUPPLEMENTS IN A CORN-SOYBEAN OIL MEAL RATION FOR GROWING-FATTENING SWINE. G. C. Anderson and R. H. Black, *West Virginia University*.

Growth trials with Duroc and Berkshire weanling pigs have been conducted to evaluate sardine condensed fish solubles (C.F.S.), sardine condensed fish solubles fortified with fish glandular hydrolysate (F.G.H.) and liver residue (L.R.) as supplements to a corn-soybean oil meal ration. Control lots received a basal ration composed of ground yellow corn 71%, soybean oil meal 25%, dehydrated alfalfa meal 2.5%, complex mineral mixture 1.0%, and a vitamin mixture of 0.5% containing riboflavin, pantothenic acid, nicotinic acid, B_{12}, A and D. Respective experimental lots received the basal ration fortified with 3% of a supplement at the expense of corn and soybean oil meal. In trial I (10 weeks) involving 55 pigs, the average daily gain and feed conversion figures for each group were: control, 1.57 lbs., 318.5 lbs.; C.F.S., 1.64 lbs., 332.9 lbs.; F.G.H., 1.59 lbs., 332.1 lbs., L.R. 164 lbs., 326.2 lbs. Pigs receiving supplements of C.F.S., and L.R. were markedly more thrifty and vigorous than were the control animals. F.G.H. also improved thrift and vigor but to a lesser extent than did the other supplements. Trials II and III have not been completed but present results are in agreement with those listed above. All trials were conducted on concrete floors and all groups were full hand-fed twice daily.

SALT AS A REGULATOR OF COTTONSEED MEAL CONSUMPTION BY BEEF CATTLE. William Archer, Jr., A. B. Nelson, Robert MacVicar and A. E. Darlow, *Oklahoma Agricultural Experiment Station*.

Grade Hereford cows (37 in 1950–51, 48 in 1951–52) were used to study the effect of self-feeding a mixture of salt and cottonseed meal to pregnant cows wintered on dry native grass. Cows hand-fed an average of 2.6 pounds of cottonseed cake per day (Lot 1) lost an average of eight pounds from the beginning of the winter feeding period until just before calving. Cows self-fed 2.6 pounds of cottonseed meal and 1.1 pounds of salt daily (Lot 2) lost an average of eighteen pounds in this period. The average yearly gain per cow in 1950–51 was 67 and 35 pounds for lots 1 and 2. The average birth weight of calves was 76 pounds in Lot 1 and 69 in Lot 2. The cows had previously produced calves which weighed 73 pounds at birth. No significant differences were found in the plasma sodium, potassium and chloride level in the cows or suckling calves or in the chloride content of the milk. The average plasma sodium, potassium, and chloride concentrations were: 301, 22, and 345 mg./100 ml., for the cows of Lot 1; and 297, 23, and 253 for the cows of Lot 2. A metabolism study was conducted with steers fed a ration of prairie hay and cottonseed meal supplemented with either 10 grams or 250 grams of NaCl. Addition of large amounts of salt did not significantly affect the coefficient of digestion of any of the nutrients. Less than one percent of the chloride fed on the high level of NaCl intakes was excreted in the feces. Urine of essentially constant chloride content was excreted by any steer receiving a high level of supplementation indicating a maximum degree of water resorption.

MOLYBDENUM TOXICITY IN THE RABBIT. L. R. Arrington and George K. Davis, *Florida Agricultural Experiment Station.*

Molybdenum as sodium molybdate ($Na_2MoO_4 \cdot 2H_2O$) was fed in a commercial ration to 40 Dutch rabbits of mixed ages and sex. When 0.1% or more molybdenum was included in the diet, gross toxic symptoms were produced. The toxic syndrome was characterized by retarded growth, loss of weight, extremely low hemoglobin and red cell counts, alopecia, slight dermatosis and death within two to three weeks. In some young rabbits a deformity of the front legs developed. The fore-legs of these rabbits weakened; they became unable to maintain their weight and both legs spread outward. There was bending and twisting of the humeri and slight swelling of the joints. Copper supplementation prevented the development of the syndrome and caused rapid recovery of those suffering from severe symptoms. All manifestations of the toxicity responded to copper therapy except the front leg deformity in which there was only slight improvement. Limited phosphorus metabolism studies using radioactive phosphorus-32 indicated that molybdenum decreased phosphorus absorption and at the same time increased the excretion of phosphorus. The relationship of molybdenum to copper was demonstrated and an interference with metabolism of phosphorus and manganese was suggested.

ANTIBIOTIC STUDIES WITH THE PIG. D. E. Becker T. S. Nelson, S. W. Terrill and J. W. Lassiter, *University of Illinois.*

Two experiments were conducted to study some aspects of the antibiotic growth response of the weanling pig in drylot. In experiment I terramycin (T), procaine penicillin (P), and bacitracin (B) were tested with a fortified corn-soybean oil meal type ration for a period of nine weeks. Treatment (mg. of antibiotic per lb. of feed), average daily gain (lb.), and feed per lb. of gain (lb.), respectively, were as follows: 1. Control, 1.15, 3.66; 2. T (15 mg.), 1.33, 3.35, 3. P (15 mg.), 1.31, 3.28; 4. B (15 mg.), 1.15, 3.53; 5. T, P, and B (5 mg. each), 1.38 3.53, and 6. T, P, and B in weekly rotation (15 mg.), 1.28, 3.44. Analysis of variance indicated the weekly rotation was not significantly superior to the controls; whereas, T and P yielded a significant response of equal magnitude. The antibiotic mixture which consistently yielded the greatest weekly weight gains during the test failed to excel T or P statistically. In experiment II, a ration of corn, soybean oil meal, alfalfa meal, condensed fish solubles, minerals, and vitamins was fed for eight weeks in drylot. The addition of 0.1% of a bacitracin supplement (5 gm. per lb.) either alone or combined with 5% dried corn distillers' solubles or 3% of a dried whey product failed to exhibit a statistically significant increase in daily gains. However, 0.05% or 0.025% of a B-P supplement (5 gm. B plus 1 gm. 1-ephenamine P per lb.) did significantly improve rate of gain.

A SEMI-SYNTHETIC RATION FOR STUDYING THE TRACE ELEMENT REQUIREMENTS OF CATTLE. Orville G. Bentley and A. L. Moxon, *Ohio Agricultural Experiment Station.*

Alfalfa ash, a trace mineral mixture, or reduced iron were used to supplement a semi-synthetic ration composed of urea, cerelose, iodized salt, calcium carbonate, calcium phosphate, vitamin A-D oil, corn and cob meal, and a poor quality, late-cut timothy hay. One hundred percent of the supplementary nitrogen or 39% of the total nitrogen was supplied by urea. Each ration was fed individually to three steers over a 140-day period. Alfalfa ash and the mineral mixtures composed of

copper, cobalt, manganese, zinc, and iron improved the average daily gains by 43% or an increase from 1.34 lb. per day (basal) to 1.92 lb. per day for the supplemented steers. The iron supplement alone had no effect on the growth performance or feed efficiency of the steers. However, the trace mineral mixture and alfalfa ash affected a saving of 77 lb. (12%) of corn and cob meal per 100 pounds of gain. None of the supplements appeared to improve the digestibility of the ration as determined by a digestion experiment using the chromium oxide marker technique. The mineral fed steers consumed on the average 25% more corn and cob meal daily indicating that appetite was improved by feeding minerals. Hemoglobin red cell volume, ammonia, urea, inorganic phosphorus, and plasma protein concentrations were all within the normal range.

SUPPLEMENTS TO POOR QUALITY HAY FOR FATTENING CATTLE. Orville G. Bentley, Earle W. Klosterman and A. L. Moxon, *Ohio Agricultural Experiment Station.*

Four experiments, with approximately 100 steers each have been conducted to determine the value of various supplements when added to a ration of late-cut timothy hay, corn and cob meal, soybean oil meal ground limestone, steamed bone meal, and salt. The steers were hand full-fed in dry lot in groups of 10 to 14 steers. Average daily gains were significantly increased when dehydrated alfalfa meal replaced the soybean oil meal or when cane molasses, molasses ash, alfalfa ash, a trace mineral mixture containing iron, copper, cobalt, manganese, and zinc, or 8 pounds of corn silage were fed with the soybean oil meal ration. Distillers dried solubles, in combination with other protein supplements, tended to improve the ration but not significantly. The inclusion of meat scraps in various amounts did not increase the rates of gain. Urea was a satisfactory source of nitrogen, although the gains were generally slower when part of the soybean oil meal was replaced by an equivalent amount of urea nitrogen. When fed with one pound of molasses the gains of steers fed three-fourths pound soybean oil meal per head daily were equal to those fed one and one-half pounds. This was not true when the same rations were fed without molasses. Rations containing good quality mixed clover and timothy hay were superior to those which contained poor quality hay.

SUPPLEMENTAL PANTOTHENIC ACID IN SMALL GRAIN RATIONS FOR SWINE. J. P. Bowland and B. D. Owen, *University of Alberta.*

A balanced ration based on barley and containing by assay an average of 2.7 mg. of pantothenic acid per lb. of feed was fed to Yorkshire swine for 2 generations. Supplemental calcium pantothenate at levels of 3 to 12 mg. per lb. of feed had no effect on first generation growth, or on gilts from the time that they were weaned until they farrowed their first litters. There was a trend to indicate that the higher levels of supplemental calcium pantothenate may have had a detrimental effect on birthweight of offspring, and on the growth of the suckling pigs. Results of microbiological assays indicated that the pantothenic acid content of the blood and milk of the sows, and the blood of the suckling pigs was related to the content of the vitamin in the sows' rations. Since barley is lower in pantothenic acid than are other small grains, any balanced small grain ration of the type commonly fed in western Canada should contain adequate amounts of the vitamin.

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EFFECT OF MINERALS ON DIGESTION OF LOW-QUALITY ROUGHAGE BY SHEEP. C. F. Chappel, R. J. Sirny, C. K. Whitehair and Robert MacVicar, *Oklahoma Agricultural Experiment Station.*

Supplementation of rations for various ruminants with complex mixtues of minerals (alfalfa ash, sea weed ash) has been reported to improve the digestibility of rations containing large amounts of various roughages of low quality. Digestion studies have been made with sheep (a total of 37 animals) in two separate experiments to confirm and extend these observations. A basal ration composed of the following major ingredients was fed: Ground corn cobs, 45 percent; ground yellow corn, 25; corn gluten meal, 20; corn sirup, 7; and corn oil, 3. All rations also contained calcium phosphate, potassium iodide, cobalt chloride, and cod liver oil. To this basal ration, various mineral mixtures were added. In all experiments, the addition of 35 gms. of alfalfa ash per head per day improved the apparent digestibility of the organic matter of the ration; this improvement was correlated with increased digestion of the crude fiber fraction. Addition of a mixture of sodium and potassium chloride plus minor elements (manganese, magnesium, zinc, iron, copper) was without effect. Supplementation with a "synthetic alfalfa ash," a mixture of purified salts compounded to resemble the mineral constituents of alfalfa, improved the digestion of total organic matter and crude fiber, but less than that noted when an equivalent quantity of alfalfa ash was fed. Addition of sodium and potassium acetate also gave some improvement. On the basis of these findings, it is suggested that the beneficial effect of alfalfa ash is primarily due to some combination of known nutreint elements, possibly by means of a buffering action against organic acids produced by fermentation in the rumen.

DETECTION OF ESTROGENIC SUBSTANCES IN ALFALFA AND CLOVER HAYS FED TO FATTENING LAMBS. Edmund W. Cheng, Charles D. Story, C. C. Culbertson and Wise Burroughs, *Iowa State College.*

Extraction of clover and alfalfa hays used in lamb fattening experiments revealed the presence of biologically active estrogenic substances. These substances were investigated with the purpose in mind that they may have considerable importance as here-to-fore unidentified factors in good quality roughages which contribute to their over-all feeding value. Unexpectedly good gains were obtained in a lamb fattening experiment in which clover hay containing estrogenic activity was fed. The implantation of diethylstilbestrol as synthetic and additional estrogenic material failed in this experiment to stimulate lamb gains beyond the good gains obtained in the control lot.

THE USE OF DIETHYLSTILBESTROL TO INCREASE NITROGEN RETENTION. M. T. Clegg, *University of Nevada.*

The remarkable gains in beef cattle which have been brought about by the use of implants of diethylstilbestrol suggest that some factor or factors are operating to alter protein metabolism. Carcass studies indicate a larger "eye" muscle and less fat deposit in the treated animals. Other work has shown no change in blood lipids which would indicate no alteration in fat metabolism. In order to test this hypothesis a nitrogen retention trial was undertaken. Four steers were used, two of which were Angus-Hereford crosses, and the others were purebred Aberdeen Angus. Two of the animals were treated with 60 mg. of diethylstilbestrol implanted subcutaneously in the ear. The other two served as controls. The steers were placed in collection stalls and composited samples of the total feed,

feces, and urine were analyzed for nitrogen by the Kjeldahl method. The collection periods were divided into 3 phases. (1) Period before treatment (2) Period 2 weeks after treatment (3) Period 4 weeks after treatment. The results verify an increase in protein anabolism. The total nitrogen retained daily by the treated steers was twice in excess of that of the controls.

RUMEN SYNTHESIS OF SOME OF THE B-COMPLEX VITAMINS IN CALVES RAISED ON THE HIGH ROUGHAGE SYSTEM. H. R. Conrad, J. W. Hibbs and W. D. Pounden, *Ohio Agricultural Experiment Station.*

A study was made of the synthesis of some of the B complex vitamins in the rumen of young dairy calves fed on different variations of the high roughage system. Composited rumen juice samples obtained by the stomach tube method three times during the day were used as the assay material. Daily urinary excretion of thiamine, pantothenic acid and riboflavin was also measured. A sharp increase in both riboflavin and thiamine synthesis occurred in the rumen as soon as the calves began to eat hay. The rumen level and urinary excretion of thiamine was significantly higher in rumen inoculated calves than in their uninoculated pair mates. The average thiamine content of the rumen juice of an inoculated calf was 27.1 micrograms per 100 ml. compared to 9.8 micrograms per 100 ml. in its uninoculated pair mate. Riboflavin and pantothenic acid synthesis in the rumen were not significantly affected by rumen inoculations. No significant differences in the thiamine and riboflavin content of the rumen juice or the daily urinary excretion were observed when various ratios of mixed legume hay to grain (4:1, 3:2, 2:3) were fed. However, thiamine synthesis was greater when 4:1 or 2:1 ratios of timothy hay to grain were fed than when either more or less grain was fed. Rumen synthesis of riboflavin increased as the proportion of grain concentrates increased up to a 2:1 ratio of timothy hay to grain. Thiamine and riboflavin levels in the rumen juice were not affected by feeding 20 mg. of aureomycin (Aurofac-2A) per pound of dry feed.

THE METHIONINE REQUIREMENT FOR THE GROWTH OF SWINE. L. V. Curtin, J. K. Loosli, Jean Abraham, H. H. Williams and L. A. Maynard, *Cornell University.*

Two individual feeding experiments were conducted to obtain additional data on the methionine requirement of swine. The basal ration consisted of isolated soybean protein, brewers' dried yeast, starch, glucose, ruffex, lard (trial A), corn oil (trial B), minerals, vitamins, and aureomycin; it contained 22% protein and 0.024% choline. In trial A, DL-methionine was added in order to have 3 rations containing 0.26, 0.36, and 0.56% methionine. A fourth ration contained 0.26% methionine and was supplemented with 0.1% choline chloride. All rations contained 0.26% cystine, and each was fed to 6 pigs. The average daily gain, feed required per 100 pounds gain, and apparently digested nitrogen retained for each of the 4 lots were 1.01, 1.07, 1.21, 1.03 pounds, 221, 204, 193, 213 pounds, and 43, 50, 52, 44%, respectively. In trial B the four rations contained 0.25, 0.45, 0.65, and 0.85% methionine, and each was fed to 5 pigs. All rations contained 0.27% cystine. The average daily gain, feed required per 100 pounds gain, and apparently digested nitrogen retained for each of the 4 lots were 0.77, 0.92, 0.85, 0.84 pounds, 231, 215, 215, 216 pounds, and 36, 42, 36, 39%, respectively. The data indicate that there was no deficiency of choline chloride in the ration. These data show that for the 22% protein ration used, the methionine requirement for growth of weanling pigs is approximaely 0.45% of the ration when the ration

contains 0.27% cystine; the methionine plus cystine requirement appears to be approximately 0.7% of the ration or 3.2% of the protein.

AMMONIATED CITRUS PULP FOR CATTLE. George K. Davis, W. G. Kirk and Henderson M. Crowder, *Florida Agricultural Experiment Station.*

Ammoniated citrus pulp prepared from citrus pulp treated with liquid amonia has been fed to cattle ranging in age from 5 months to 2 years. Experiments carried out in 1945, 1946, and 1952 have demonstrated that (1) palatability is markedly affected by the method of preparation, (2) older cattle accept and utilize the product better than calves, (3) 12% crude protein ammoniated citrus pulp may supply up to 30% of the total digestible nutrients for young cattle and up to 50% of the T.D.N. for older cattle with efficient utilization of the non-protein nitrogen.

EFFECT OF INITIAL LEVEL AND RATE OF INCREASE OF ARTIFICIALLY DEHYDRATED ALFALFA IN COMPLETE RATIONS ON GROWTH AND CAROTENE INTAKE OF HOLSTEIN DAIRY CALVES. K. L. Dolge, H. D. Eaton, F. I. Elliott, Geoffrey Beall and L. A. Moore, *University of Connecticut and U. S. Department of Agriculture.*

Thirty-six 7-day old, male Holstein calves were fed mixtures of alfalfa pellets and starter pellets *ad libitum* and limited whole milk. The alfalfa-starter pellet mixtures contained initially 10, 15, 20, or 25% alfalfa pellets. While holding the parts of starter constant in each of these initial mixtures, the parts of alfalfa were increased at the weekly rates of 1.0000, 1.1747 and 1.3494. Alfalfa-starter consumed from day-7 through day-91 was calculated to be maximum at the initial level of 18.33% and at a rate of increase of 1.2149. Dry matter efficiency was found to be inversely related to both initial level and rate of increase. T.D.N. efficiency, however, was calculated to be greatest at the initial level of 18.08% and a rate of increase of 1.2336. Average carotene intake/mean lb. body weight was directly related to the amount of alfalfa in the ration. Calves on the average received <60 γ of carotene/mean lb. body weight/day for 2.1 ± 0.2 wk. This decreased as initial level and rate of increase became greater. Carotene utilization was similar for all treatments but storage was directly related to rate of increase. Increase in live weight, height at withers, heart girth, and girth of paunch were greatest for those receiving the initial levels of 15 and 20%. Maximum gain in live weight was calculated to be at an initial level of 16.99% and at a rate of increase of 1.1817. Neither hemoglobin nor plasma vitamin A was related to initial level or rate of increase. Plasma carotene reflected carotene intake.

CERTAIN SURFACE ACTIVE AGENTS ACCELERATE THE RATE OF GAIN OF PIGS FED A CORN-COTTONSEED MEAL RATION. I. A. Dyer, T. J. Davis, and A. E. Cullison, *University of Georgia.*

Four groups of 10 comparable weanling pigs each were self-fed, in drylot, a 20% crude protein ration consisting of corn, degossypolized cottonseed meal, minerals, the necessary vitamins and aureomycin. The rations of groups 2, 3 and 4 were further supplemented with Ethomid C/15–16 (1% of the diet), E-800 (.2%) and E-800 (.2%) plus sodium tripolyphosphate (.2%) respectively. Rates of gain to approximately 100 pounds liveweight were 0.90, 0.99, 1.12 and 0.94 pounds per day for groups 1, 2, 3 and 4 respectively. Feed efficiency for groups 1–4 was 391, 373, 354 and 332 pounds per 100 pounds gain respectively.

BLOOD LEVELS AND RETENTION OF CALCIUM MAGNESIUM AND POTASSIUM IN LAMBS ON NORMAL AND HIGH POTASSIUM DIETS. H. D. Eaton and J. E. Avampato, *University of Connecticut.*

Twelve lambs were fed three rations in a four period rotational scheme (Lucas '48) with restricted feed intake. These rations consisted of I, "Normal" alfalfa hay containing 1.60±0.04 g.% K, 1.58±0.03 g.% Ca, 0.32±0.01 g.% Mg; II, "High-K" alfalfa hay containing 3.23±0.03 g.% K, 0.62±0.01 g.% Ca, 0.25±0.01 g.% Mg; and III, "Normal" alfalfa plus sufficient KCl to make the K intake equal to I. Venous blood samples were drawn every 2nd week during each of the four eight week periods. Results of blood analysis for rations I, II, and III respectively were as follows: hematocrit, 34.82, 35.12 and 35.28% with a least significant difference (LSD.) at P=0.05 of 0.44; hemoglobin, 10.57, 10.57 and 10.62 g.% with a LSD. of 0.30; whole blood K, 35.48, 36.37 and 36.59 mg.% with a LSD. of 0.93; serum K, 20.60, 21.87 and 21.11 mg.% with a LSD. of 0.59; serum Ca, 10.21, 9.99 and 10.28 mg.% with a LSD. of 0.12; and serum Mg, 2.65, 2.61 and 2.75 mg.% with a LSD. of 0.03. Two 7-day balance trials during each of the four periods indicated that for K there was 40.22 g. retained/7-day period for I, 126.43 for II and 126.74 for III with a LSD. of 9.87. For Ca there was 3.19 g. retained/7-day period for I, 3.82 for II and 0.41 for III with a LSD. of 0.81 and for Mg 2.65, 3.27, and 1.97 respectively with a LSD. of 0.97. Body weight transformed to logs showed no treatment differences.

BLOOD PYRUVATE AS A CRITERION OF THIAMINE DEFICIENCY IN GROWING SWINE. R. M. Forbes, *University of Illinois.*

Six 7-week-old pigs were placed in metabolism cages at 85° F. and 70 percent humidity. The basal diet contained 20 parts vitamin-free casein, 5 of corn oil, 6 of woodflock, minerals, vitamins except for thiamine, and equal parts of glucose and starch. The diet was fed according to appetite. For the first week all pigs received 1.5 mcg. of thiamine per gm. of diet. Thereafter, 2 pigs served as positive controls, receiving either 5 or 10 mcg. of thiamine per gm. of diet. After the first week the remaining pigs received no thiamine until an incipient deficiency, detected by elevated blood pyruvate levels, developed. Within 14 days the blood pyruvate levels of the thiamine-deficient pigs had increased from a normal value of 2.37 mg. per 100 ml. to 3.42. Six days later it was 5.62 and the food intake of the pigs had dropped from 4.68% to 2.58% of their body weight. The pigs were then given 2 mcg. of thiamine per gm. of feed. Within one week the food intake was above 4% of body weight, and within 10 days the blood pyruvate had decreased to 2.70 mg. per 100 ml. This value was not altered by raising the thiamine intake to 3 or to 10 mcg. It is significant that markedly elevated blood pyruvate levels preceded appetite failure in pigs subjected to sub-optimum intake of thiamine.

GROWTH STIMULANTS AND *AD LIBITUM* FEEDING IN THE PRODUCTION OF MILK-FED VEAL. K. E. Gardner, W. B. Nevens, T. Folkerts and B. Connor Johnson, *University of Illinois.*

Bull calves of five dairy breeds were left with their dams for three days and then fed three times daily *ad libitum* by nipple pail on Holstein milk through the age of 56 days. The control group received milk only. Three experimental groups received in their milk one of the three supplements: Crystalline aureomycin at the rate of 15 mg. per pound of milk, pure procaine penicillin at the same rate, or a surface active agent "Ethomid C-15" at a rate of .05 gm. per pound

milk. Few instances of scours occurred in any group. By the age of 6 weeks, calves were consuming milk at the rate of 15 to 18 lb. per 100 lb. live weight daily. Milk required per pound gain, in addition to colostrum, varied from 8 to 11 lb. Aureomycin supplementation produced improved gains, whereas penicillin and the surface active agent appeared to have no effect. The calves were slaughtered and federally graded. It was found possible to produce good and choice veal from dairy calves by pail feeding milk *ad libitum*.

COMPARISON OF DIFFERENT LENGTH PRELIMINARY AND COLLECTION PERIODS IN DIGESTION TRIALS WITH LAMBS FED CHOPPED ALFALFA HAY. Glen Hall and P. G. Woolfolk, *University of Kentucky*.

To determine the effects that different lengths of preliminary and collection periods have on the amount of daily excreta, chemical composition of excreta, and the resulting coefficients of apparent digestibility, a 20-day digestion experiment was subdivided into trials of the following lengths for each of 6 lambs used: 3-day preliminary–3-day collection; 3-day preliminary–6-day collection; 5-day preliminary–5-day collection; 5-day preliminary–10-day collection; 10-day preliminary–5-day collection; and 10-day preliminary 10-day collection. The lambs, ranging in weight from 36 to 84 pounds, were placed in individual pens and fed twice daily. Each of 5 lambs received 455 gms. of chopped alfalfa hay per feeding while a smaller lamb was fed 355 gms. at each feeding. The average coefficients of apparent digestibility varied very little among the different trials with no significant differences occurring. The average chemical composition of the feces from the different trials never in any case exceeded the maximum differences allowed by an analyst for duplicate samples of the same material. Variations that occurred in digestion coefficients among the trials were due mainly to variation in daily fecal excretion rather than to variation in chemical composition of the feces. The results of this experiment indicate that preliminary and collection periods as short as 3 days each in digestion trials with lambs taken off pasture and fed chopped alfalfa hay give results comparable to those obtained in trials consisting of preliminary and collection periods as long as 10 days each.

RIBOFLAVIN, NIACIN, AND CALCIUM PANTOTHENATE AS SUPPLEMENTS TO A MIXED RATION FOR GROWING PIGS. L. E. Hanson and E. F. Ferrin, *University of Minnesota*.

Two experiments have been completed to study the adequacy of the ration used with respect to riboflavin, niacin and pantothenic acid when fed to pigs in paved lots. The ration was composed of ground yellow corn supplemented with a mixture of soybean meal, tankage, linseed meal, dehydrated alfalfa meal, steamed bone meal, iodized salt and vitamin B_{12} and aureomycin supplement (Aurofac). The respective vitamins were added singly and in all possible combinations. The pigs used in the first experiment included several runts on each treatment and the average initial lot weight was only 24.4 lbs. In the second experiment the average initial weight was 34 lbs. Enough supplement was added to the corn to provide an 18% protein ration from weaning to 125 lbs. average weight per pig. A 15% protein ration was fed from 125 lbs. to 200 lbs. average weight per pig. The results were very similar in both experiments. The daily rate of gain and feed requirement per 100 lbs. of gain, respectively (an average of both experiments), was as follows: negative controls 1.62–360; riboflavin, 1.59–361; niacin, 1.56–359; Ca pantothenate, 1.62–352; riboflavin and niacin 1.54–350; riboflavin and Ca pantothenate 1.56–356; niacin and Ca pantothenate,

1.60–356; positive controls-riboflavin, niacin and Ca pantothenate, 1.57–347. It is concluded that the mixtures fed were adequate in riboflavin, niacin and pantothenic acid.

THE VALUE OF ANTIBIOTICS IN PIG STARTERS FOR SUCKLING PIGS. L. E. Hanson and E. F. Ferrin, *University of Minnesota.*

Seventy-nine litters of pigs were used to study the value of various antibiotics as additions to simple formula pig starters fed in a creep. Aureomycin, bacitracin, procaine penicillin and terramycin were the antibiotics tested. In 1951, the pig starter was composed of 40% ground yellow corn, 40% rolled oats, 10% dry rendered tankage, 9.5% soybean meal and 0.5% iodized salt. In these trials aureomycin and terramycin supplements stimulated the growth rate of the pigs to which each was fed. Bacitracin as fed did not affect the rate of gain. In other tests procaine penicillin did not affect the growth rate of pigs to which it was fed. In all of the 1951 trials the antibiotic level was 5 mg. per lb. of feed. In 1952, the pig starter consisted of 60% ground corn, 30% rolled oats, 5% dry rendered tankage, 4.5% soybean meal, 0.5% iodized salt, and 0.5 mg. vitamin B_{12} per 100 lbs. of starter. In the first test 20 mg. of penicillin per pound of starter produced pigs that had an 8 week weight of 44.3 lbs. as compared with 35.1 lbs. for the controls. In the second test levels of zero, 5, 10 and 20 mg. levels of penicillin were fed. The respective weaning weights at 7 weeks were 27.3, 33.5, 30.2 and 31.2 lbs. per pig. In two later trials penicillin was fed at 2.5 mg. level and did not produce a marked response. It is concluded that aureomycin, procaine penicillin and terramycin are effective, when fed in a pig starter at a level of 5 mg. or more per pound of feed, in increasing the growth rate of suckling pigs.

IMMATURE CORN FOR GROWING-FATTENING PIGS. Charles J. Heidenreich and Richard F. Wilson, *South Dakota State College.*

In previous experiments conducted to determine the feeding value of soft corn, no differentiation has been made between "mature" and "immature" soft corn. For this study maturity has been designated as the time when grain yields no longer increase (moisture-free basis) and occurs approximately when kernel moisture equals 34–40%. On the basis of this description, all previous work at this station has been conducted with "mature" soft corn. Three lots of 15 pigs each were self-fed in the winter and early spring of 1952 as follows: Lot I, No. 1 shelled yellow corn; Lot II, artificially dried immature shelled yellow corn which contained 49.8% moisture before drying and 17.1% when fed; and Lot III, wet immature shelled yellow corn containing 49.8% moisture. Fifteen pigs were hand-fed wet immature ear corn (49.6% kernel moisture) in Lot IV. The average daily gains made in Lot I (1.86 lb.) were not significantly greater than those made in Lot II (1.73 lb.) nor was there a significant difference between Lot II and Lot III (1.67 lb.). Differences between Lots I and IV (1.52 lb.) and Lots II and IV were highly significant ($P<0.01$). All other differences in daily gain were significant ($P<0.05$). Lots II and III consumed 27.7 and 12.4% less protein supplement respectively than Lot I whereas Lot IV required 2.7% more. When all corn was compared on a shelled, dry matter basis, the grain requirements per 100 pounds gain were: Lot I, 308.4 lb.; Lot II, 377.3 lb.; Lot III, 300.7 lb.; and Lot IV, 384.0 lb. These results indicate that artificial drying of "immature" corn increases the grain dry matter requirements 25.5% over that of immature corn fed in the wet state.

VITAMIN AND AMINO ACID SUPPLEMENTATION OF CORN-TANKAGE RATIONS FOR GROWING PIGS. Jess N. Henson, W. M. Beeson, and T. W. Perry, *Purdue University.*

Two experiments were conducted to determine the value of supplementing a corn-tankage ration with vitamins, antibiotic and amino acids. In the first trial the effects of supplementing a basal ration of corn, tankage, salt and vitamin A and D oil with 3 B-vitamins (riboflavin, calcium pantothenate and niacin), vitamin B_{12} and terramycin were studied. The treatments, their respective daily gain and feed required per 100 lbs. gain during the 99 day feeding trial were as follows: (1) Basal, 0.84, 472; (2) Basal+3 B-vitamins 1.42, 329; (3) Basal+vitamin B_{12}, 1.11, 409; (4) Basal+terramycin, 1.19, 385; (5) Basal+vitamin B_{12} and terramycin, 1.37, 340 and (6) Basal+3 B-vitamins, vitamin B_{12} and terramycin 1.66, 337. Pantothenic acid deficiency symptoms occurred in groups 1, 3 and 4. The second experiment was designed to determine whether or not diet 6 above could be improved by amino acid supplementation, and to compare tankage with meat and bone scraps. The treatments, their respective daily gain and feed required per 100 lbs. gain for the first six weeks were as follows: (1) Tankage Basal (same diet as group 6 above), 1.04, 327; (2) Meat Scrap Basal, 0.81, 356; (3) Tankage Basal+0.6% DL lysine-HCL, 1.07, 303; (4) Tankage Basal+0.2% DL methionine, 0.91, 323; (5) Tankage Basal+0.1% DL tryptophan, 1.29, 305; (6) Tankage Basal+0.6% DL lysine HCL, 0.2% DL methionine and 0.1% DL tryptophan, 1.30, 293 and (7) Meat Scrap Basal+0.6% DL Lysine-HCL, 0.2% DL methionine and 0.1% DL tryptophan, 1.33, 285. Tryptophan appears to be the limiting amino acid in a tankage ration.

CHANGES IN THE BLOOD SUGAR LEVEL AND VOLATILE FATTY ACID CONTENT OF THE RUMEN JUICE IN CALVES RAISED ON THE HIGH ROUGHAGE SYSTEM. J. W. Hibbs, H. R. Conrad, and W. D. Pounden, *Ohio Agricultural Experiment Station.*

A study was made of the changes occurring in the blood sugar level and of the total volatile fatty acid content of rumen juice during the first 12 weeks following birth in calves raised on the high roughage system, which is designed to develop early rumen function. Whole milk was fed at the rate of one pound per 10 pounds of birthweight for six weeks and then tapered off to zero by the end of the seventh week. Good mixed legume hay was fed free choice with a simple grain mixture in various ratios (4:1, 3:2, 2:3), the amount of grain fed being governed by the amount of hay eaten. Cud inoculations given weekly for the first six weeks served as an early, reliable source of rumen microorganisms. The blood sugar level was found to decrease from 80–100 mg. per 100 ml. to 45–65 mg. per 100 ml. during the first eight weeks and continued at this level to 12 weeks of age. No differences were noted which could be attributed to the proportion of hay to grain fed. Calves fed 20 mg. of aureomycin per pound of dry feed (Aurofac-2A) maintained a blood sugar level approximately 9 mg. per 100 ml. higher than the controls from eight to 12 weeks. Calves fed all milk with no roughage remained in the 70–85 mg. percent range. That the decrease in blood sugar during the first eight weeks was associated with the development of rumen function is indicated by the observed increase in the total volatile fatty acid content of the rumen juice to the maximum level during this period.

THE RESPONSE OF WEANLING PIGS TO DIFFERENT METHODS OF FEEDING. J. A. Hoefer, R. W. Luecke and F. Thorp, Jr., *Michigan State College.*

In this study comparisons were made using complete mixed rations, rations of shelled corn with supplement free-choice, and pelleted rations. All rations were self-fed and consisted basically of corn, soy bean meal, fish solubles, dried whey, complex mineral mix, B_{12}, supplementary B vitamins, antibiotic supplement and a vitamin A and D concentrate. To test the effect of ration quality on feed choice as well as animal performance the supplementary B vitamins and the antibiotic were omitted from two rations. Sixty Duroc pigs (average wt. 25.5 lbs.) were divided into six uniform lots and fed as follows: Lot 1, complete mixed ration; Lot 2, shelled corn plus complete supplement free-choice; Lot 3, mixed ration (B vitamins and antibiotic omitted); Lot 4, shelled corn plus supplement free-choice (B vitamins and antibiotic omitted); Lot 5, complete mixed ration pelleted; and Lot 6, shelled corn plus complete supplement pelleted free-choice. After nine weeks the average daily gains and feed efficiency figures (lbs. feed per lb. gain) for the six lots were as follows: Lot 1, 1.27 and 2.18; Lot 2, 1.31 and 2.69; Lot 3, 1.10 and 2.57; Lot 4, 1.28 and 2.22; Lot 5, 1.39 and 2.38; Lot 6, 1.42 and 3.13.

VITAMIN B_{12} METABOLISM IN THE SHEEP. W. G. Hoekstra, A. L. Pope, and P. H. Phillips, *University of Wisconsin.*

The relationship of vitamin B_{12} to cobalt deficiency in the sheep was investigated. Vitamin B_{12} concentrations of the blood, livers, and rumen ingesta were determined by microbiological assay for three groups of sheep. Riboflavin and niacin were also determined in the rumen ingesta to investigate the possibility of a general inhibition of vitamin synthesis. Lot 1 received *ad libitum* a basal cobalt-deficient ration (0.045 ppm Co); lot 2, the basal ration *ad libitum* plus supplemental cobalt (mixed in the salt); and lot 3, the basal ration plus cobalt but limited in amount of feed ingested to that of the lot 1 animals. The average vitamin B_{12} concentrations for lots 1, 2, and 3 respectively were as follows: 0.47, 2.3, and 4.3 m.μg vitamin B_{12}/cc. whole blood; 0.03, 0.92, and 1.20 μg "true" vitamin B_{12} activity/gm. moist liver; 0.09, 1.3, and 1.3 μg vitamin B_{12}/gm. dry rumen contents. Riboflavin and niacin concentrations of the rumen ingesta were essentially the same in the three lots. Sheep in severe cobalt deficiency were given intravenous injections of 20 μg of vitamin B_{12} twice per day for 21 days. This treatment was followed by a rise in blood vitamin B_{12} to "near normal" values, immediate and remarkable responses in feed consumption, vigor, and body weight gains, and return of blood hemoglobin concentrations to normal within 40–60 days. A second series of vitamin B_{12} injections when cobalt deficiency symptoms again appeared brought similar response. These data suggest that vitamin B_{12} is by far the most important, if not the only, limiting factor in the cobalt-deficient sheep.

TOLERANCE OF YOUNG DAIRY CALVES TO COTTONSEED MEALS PREPARED BY DIFFERENT PROCESSES. B. F. Hollon, R. K. Waugh, and G. H. Wise, *North Carolina State College.*

Two types of cottonseed meals, a special expeller meal containing 41% protein and 0.059% free gossypol and a commercial hydraulic meal containing 41% protein and 0.173% free gossypol were compared as components of calf starters. Each meal was tested at two different levels, 40% and 60% of the starter. The 4 resulting starters were fed, with alfalfa hay, to comparative

groups of calves (3 Holsteins and 1 Jersey). Whole milk, fortified with vitamins A and D was fed from 3 days to 35 days of age, and starters until either death or 180 days. At 35 days of age, each calf was consuming daily a minimum of 1 lb. of starter and about 2 lb. of hay. Rough hair coats and paunchiness were common to all calves, but weight gains were similar in all groups until symptoms of toxicity were manifested. The calves most thrifty in appearance were the first affected. Nine calves were lost between 49 and 130 days of age: 3 from diets containing the expeller-process low-gossypol meal (all at the high level) and 6 from the hydraulic, high-gossypol meal (4 at the high level and 2 at the low). Ante-mortem symptoms included poor appetite, abdominal pains and dyspnea. Autopsy revealed accumulations of serous fluid in the thoracic and the abdominal cavities. Edema was found in all animals, suggillations in the heart valves of 3 and hepatization in the lungs and the liver of 2. The amount of the respective meals that the calves could tolerate apparently was determined by the gossypol content.

THE MINIATURE ARTIFICIAL RUMEN AND ITS USES. C. N. Huhtanen and L. S. Gall, *National Dairy Research Laboratories, Inc.*

Several types of artificial rumen are used in rumen digestion research. Only the type described by Louw (1949) using a permeable sack has been shown to support viable true rumen bacteria. This apparatus is cumbersome and hard to sterilize, as are the attachments used for gassing and neutralization. Periodic adjustment of the pH is necessary. The miniature artificial rumen is a simpler apparatus with no attachments. The volume of the permeable sack and outer bath is 100 ml., about 1/15 of the larger type. The outer bath fluid is essentially McDougall's synthetic saliva (1948) plus a cysteine-bicarbonate solution gassed with CO_2 which creates the proper Eh, pH and osmotic pressure and maintains these critical factors within desirable limits for a week if proper amounts of substrate are used. The smaller apparatus is easier to handle and sterilize; and the improved outer bath fluid eliminates the need for neutralization and gassing. Since many miniature artificial rumens can be handled in the time needed to run one large rumen, more repeat determinations can be run using the smaller rumen. This apparatus is excellent for pure culture studies because it requires a smaller inoculum and substrate. Since many rumen oganisms are difficult to grow, a small inoculum is easier to build up. The amount of substrate used is small enough to permit the use of the entire sample for analysis, eliminating the need for aliquots. The small artificial rumen is used in studies requiring repeated serial transfers and for evaluating feedstuffs and supplements.

RELATIONSHIP OF GROWTH OF DAIRY CALVES TO LENGTH OF MILK FEEDING PERIODS. R. N. Jarvis, R. K. Waugh, and W. R. Murley, *North Carolina State College.*

During a 5 yr. period, 59 Guernsey and Jersey heifer calves were divided at birth into 4 dietary groups and fed milk for either a 3 (plus a commercial milk replacement), 7, 9 or 12 wk. period. In addition all calves received alfalfa hay *ad libitum* and a complete calf starter to 4 mo. and a more simple concentrate mixture (calf grower) to 6 mo.; the two latter feeds being limited to 4 lb. daily. To 6 mo. of age the calves exhibited an average daily gain of 1.01, 1.00, 1.05 and 1.16 lb., respectively; the 3 former groups being below the Ragsdale growth standard. The average feed consumption per calf was: milk, 65, 260, 361 and 537; calf starter, 189, 218, 212 and 215; and calf grower, 218, 230, 233 and 239 lb. respectively. Assuming a uniform consumption of hay, which was not

measured, and taking a standard price for milk and other feeds, the feed cost per calf to 6 mo. was $39.90, $45.48, $50.23 and $59.46 respectively. The calves on the milk replacement diet gained at a slower rate to 10 wk. of age than the calves fed the greatest amount of milk, and at a parallel rate to 6 mo. at which time they were an average of 28 lb. lighter. The calves receiving 260 lb. milk gained at a rate similar to the higher levels of milk feeding to 6 wk. at which time a reduced rate of growth began and became increasingly greater to 6 mo. More diarrhea, infections and a rougher appearance were encountered among the calves fed the milk replacement than any of the other dietary groups. Of interest, also, was the noticeable lack of appetite, which was indicated by the lower consumption of the concentrate mixtures by those calves than by the others.

EFFECTS OF ANTIBIOTIC AND LYSINE SUPPLEMENTATION ON DIFFERENT PROTEIN LEVELS FOR GROWING-FATTENING SWINE. A. H. Jensen, G. C. Ashton, H. M. Maddock, P. G. Homeyer, and D. V. Catron, *Iowa Agricultural Experiment Station.*

Corn-soybean oil meal rations fortified with vitamins and minerals were fed to 144 Duroc and Poland China x Landrace x Duroc weanling pigs. Respective lots of 4 pigs each received a 10, 12, 14, 16, 18 or 20% protein ration from 35.6 to 200 lbs. On each protein level two lots of pigs received aureomycin and two received terramycin, each at the rate of 5 mg. per lb. of total ration. Daily gains increased significantly with increasing protein levels up to 14%, with or without antibiotic. Higher protein levels did not produce further increases in daily gains. From starting weight to 75 lbs. the pigs on all protein levels receiving terramycin gained significantly more per day (0.14 lb.) than did those pigs receiving no antibiotic. Over the entire feeding period, however, neither antibiotic produced a greater rate of gain than did the basal ration. One pig from each lot except the 20% protein lots was slaughtered. There were no significant differences in degree of carcass fatness between the basal- and antibiotic-fed pigs as measured by live back fat, carcass back fat and specific gravity. As measured by specific gravity but not by thickness of back fat, there was a significant decrease in carcass fatness as the protein in the ration was increased up to 16%. Ten and 12% protein rations supplemented with 3 levels of lysine were fed to pigs in individual wire-floored pens. The 10% protein ration was inadequate regardless of the level of lysine added. When 0.09% lysine was added to the ration palatability was decreased.

ACTIVATED SEWAGE SLUDGE AS A SOURCE OF VITAMIN B_{12} FOR THE PIG. B. Connor Johnson and H. E. Schendel, *University of Illinois.*

By using an alpha-protein synthetic milk ration it has been previously demonstrated that the pig requires vitamin B_{12} (JOURNAL OF ANIMAL SCIENCE 7:528 (1948), Jour. Biol. Chem. 178:1001 (1949)). Recently Hoover, Jasewicz and Porges (Science 114:213 (1951)) have shown that dried activated sewage sludge contains by microbiological assay up to approximately 6 μg of vitamin B_{12} activity per gram. Several different compounds having varying microbiological and animal vitamin B_{12} activity have recently been reported to be present in feces, rumen contents, etc., and formed by microbial fermentation. Thus it seemed worthwhile to study with animals the vitamin B_{12} activity of sewage sludge. In addition to the question of the animal activity of the vitamin B_{12} present, there was on the one hand the possibility of toxic or inhibitory substances being present and on the other, that possibility of additional unidentified growth factors being present.

In two experiments the vitamin B_{12} of dried activated sewage sludge has been found readily available for, and active in, promoting the growth of baby pigs on the vitamin B_{12}-deficient diet, and in addition the sewage sludge gives some evidence of possessing additional growth-promoting properties when compared to pure vitamin B_{12}. No evidence of toxicity was found when the dried sludge was fed at a level of 2% of the dry matter of the ration.

EFFECT OF UREA ON PREGNANT EWES. R. M. Jordon, *South Dakota State College.*

Following breeding, pregnant ewes were fed brome hay and received the following protein supplements to balance their ration: Group I, soybean meal, Group II, protein supplement containing 5% urea, Group III, protein supplement containing 10% urea. The protein to which the two levels of urea was added consisted of soybean meal and dehydrated alfalfa, and soybean meal and wheat mids. Results of three years work will be presented on what effect the two levels of urea had on the productiveness of the ewes when compared with soybean meal. The protein supplement was fed so as the amount of protein received was equal. Results of three years work are presented. The gain made by the ewes during the gestation period was practically the same in all lots regardless whether they received soybean meal or protein supplement plus 5 or 10% urea. Neither was the fleece weight affected by the kind of protein supplement fed.

Ewes receiving soybean meal, protein supplement plus 5% urea and protein supplement plus 10% urea lambed 110%, 108% and 101% respectively. Percent lambs weaned was 84 in all lots. Percent dry ewes was 24, 23 and 17 in the soybean meal, 5% urea and 10% urea groups, respectively. Average daily gain of lambs on pasture was .423, .427 and .458 pound per lamb daily for the lamb suckling the ewes that had received soybean meal, 5% urea, and 10% urea, respectively.

EFFECT OF TERRAMYCIN ON GROWTH AND RUMEN FUNCTION IN HOLSTEIN CALVES. E. M. Kesler and C. B. Knodt, *The Pennsylvania State College.*

Crystalline terramycin was added to the diet of male Holstein calves at the rate of 20 mg. per 100 pounds of body weight daily. Six calves were fed the antibiotic which was incorporated into their milk replacement diet. At the age of 8 weeks, when replacement feeding ceased, 3 of the calves were continued on terramycin feeding by capsule, while the other three received no antibiotic. Six replacement fed controls received no antibiotic until the age of 7 weeks when 3 of them were placed on terramycin *via* capsule at the same rate. In addition, 3 milk fed control calves were observed. Duration of the trial was 16 weeks. Calves fed terramycin gained in body weight at a faster rate during the first 8 weeks than did replacement fed controls, being 22.7% heavier at that time. However, body weight gain of milk fed calves was equal to terramycin fed ones. Cessation or initiation of terramycin feeding had little effect on growth after 8 weeks of age. The antibiotic appeared to stimulate the appetite for calf starter in the young animal. Rumen samples were obtained from all calves at the ages of 12 and 16 weeks and cellulose digestion was determined in an artificial rumen. Samples from calves being fed terramycin showed consistently lowered ability to digest cellulose (24.2%) as compared to control calves which digested an average of 67.4%. No differences in levels of thiamine and riboflavin were noted in rumen samples obtained from the calves at 6, 12, and 16 weeks of age.

ANTIBIOTICS IN CREEP RATION OF SUCKLING LAMBS. D. M. Kinsman and W. H. Riddell, *Vermont Agricultural Experiment Station.*

Forty-nine suckling lambs were divided into 5 groups, and each fed the same basic creep ration of corn, oats, bran, and linseed meal. In addition, four of the groups received antibiotics at the rate of 15 mg. per pound of concentrates, group I, aureomycin; II, terramycin; III, penicillin; IV, control; and group V, terramycin and vitamin B_{12}. The trial lasted 8 weeks. There was no appreciable difference in rates of daily gain among the groups for the period, the extremes being 0.511 pounds for group 1 and 0.546 pounds for group V. Some difference was noted in the amount of feed consumed per pound of gain as follows: Group I, 2.83 pounds; II, 2.88; III, 3.48; IV, 3.12 and group V, 3.17 pounds. In general all groups were on a par in thriftiness and condition.

UREA AND COTTONSEED MEAL IN THE FATTENING RATION. W. G. Kirk, *Range Cattle Experiment Station.*

Protein is the nutrient most deficient in Florida feeds. To determine if "Two-Sixty-Two" (urea) could replace the protein of cottonseed meal when combined with citrus feeds, six trials of 120 days have been completed, four in dry lot and two on native pasture. Twelve calves and 12 short yearling steers were fed individually in dry lot. Lot 1 was fed hay, cottonseed meal, citrus pulp and citrus molasses while Lot 2 was fed the same ration except that cottonseed meal was replaced with a mixture containing 60 parts cottonseed meal, 5.5 parts urea and 34.5 parts citrus pulp. In two trials calves fed cottonseed meal made an average daily gain of 2.04 pounds and yearlings 2.53 pounds and required 472 and 426 pounds T.D.N. respectively for 100 pounds gain. Calves fed the cottonseed-urea mixture gained an average of 1.81 pounds daily and yearlings 2.45 pounds and required 511 and 443 pounds of T.D.N. respectively for 100 pounds gain. Two lots of four yearling steers were fed in Trial 1 and four yearling heifers in Trial 2 on native pasture. Lot 1 fed citrus molasses free-choice and 1.65 pounds cottonseed daily per animal gained 1.68 pounds per day while Lot 2 fed citrus molasses containing three percent urea and one pound daily per animal of citrus meal made an average daily gain of 1.59 pounds. The citrus meal fed to Lot 2 was equivalent to the non-protein nutrients in the cottonseed meal fed Lot 1. Lot 1 required 361 pounds T.D.N. from the supplemental feed for 100 pounds gain and Lot 2, 390 pounds.

THE GROWTH RESPONSE OF WEANLING PIGS FED LOW PROTEIN RATIONS TO CALCIUM PANTOTHENATE AND AUREOMYCIN. R. W. Luecke, J. A. Hoefer and F. Thorp, Jr., *Michigan State College.*

Published work with laboratory animals has indicated that antibiotics may exert a sparing action on the animals' requirement for certain B vitamins. In the present experiment 60 weanling pigs averaging 25.1 lbs. were divided uniformly into 6 lots. The basal ration used was composed of corn, 81.8%; soybean oil meal, 13.0%; fish solubles, 2%; complex mineral mixture, 3.2%; vitamins A and D, and niacin, riboflavin, pyridoxine, thiamine and vitamin B_{12}. The crude protein content of the basal ration averaged 15.4% and the pantothenic acid content was found to be 5.25 mg./lb. The following experimental treatments were used: Lot 1, basal; lot 2, basal + aureomycin 5 mg./lb.; lot 3, basal + calcium pantothenate, 2 mg./lb.; lot 4, basal + aureomycin, 5 mg./lb. + calcium pantothenate, 2 mg./lb.; lot 5, basal + calcium pantothenate, 4 mg./lb.; lot 6, basal + aureomycin, 5 mg./lb. + calcium pantothenate, 4 mg./lb. The average daily gains and feed efficiency, in parentheses, at the end of ten experimental weeks were as

follows: lot 1, 1.15 (3.10); lot 2, 1.24 (3.14); lot 3, 1.35 (2.96); lot 4, 1.58 (2.92); lot 5, 1.38 (2.98); lot 6, 1.43 (2.92). Locomotor incoordination developed in lots 1 and 2 and was more severe in pigs of lot 2 fed supplementary aureomycin. It is concluded that aureomycin does not spare the pigs requirement for pantothenic acid.

CONCENTRATIONS OF AUREOMYCIN IN SOWS' BLOOD AND MILK AFTER ORAL ADMINISTRATION OF AUREOMYCIN HYDROCHLORIDE. H. M. Maddock, V. C. Speer, P. W. W. Cuff, G. C. Ashton and D. V. Catron, *Iowa Agricultural Experiment Station.*

Three experiments involving 13 Duroc sows have been conducted to study the absorption of aureomycin hydrochloride by the blood and its transfer to the milk. No appreciable concentrations of the antibiotic were detectable in the sows' blood serum or whey 8 hours after feeding levels of aureomycin from 2.5 to 20 mg. per pound of ration each for one week. In the second experiment, single oral doses per sow of 0.5, 1.0, 2.0 and 4.0 gm. were given by capsule with bleeding and milking 8 hours later. A maximal serum aureomycin level of 0.75 mcg. per ml. was produced by the 4.0-gm. dose. Aureomycin was greatest in the whey, 2.21 mcg. per ml., when 2.0 gm. were administered per sow. The concentrations of aureomycin in the blood serum and whey resulting from the different levels of administration were significantly different at P=0.01. The sows in Experiment III were bled and milked 6 hours after the administration by capsule of 1.5, 3.0, 4.5 and 6.0 mg. of aureomycin per pound of body weight. The highest concentration in the blood serum, 0.83 mcg. per ml., resulted from the 4.5-mg. level or an average dose of 1949 mg. of aureomycin per sow. The average values resulting from the levels administered were different as determined by the significant quadratic regression (P=0.05). Average concentrations of aureomycin from 0.60 to 1.49 mcg. per ml. were found in the sows' milk but there were no significant differences between the levels. The correlation coefficient between serum and milk aureomycin values in Experiments II and III were not significant at P=0.05.

THE VALUE OF SEVERAL AMMONIATED PRODUCTS AS FEED FOR BEEF CATTLE. Ralph McCall and W. R. Graham, Jr., *The Quaker Oats Company.*

Various ammoniated protein substitute products have been compared with natural proteins in fattening experiments involving 251 steers in four experiments. The ammoniated products include: citrus pulp, molasses, and a saccharified by-product from furfural production (Furafeed). The ammoniated citrus pulp and ammoniated molasses had approximately 25% protein equivalent and the Furafeed 35% protein equivalent. Steers fed a protein supplement in which Furafeed supplied approximately 1/5 of the protein, made 0.08 lb. more daily gain than those on the supplement having similar protein replacement by urea, with almost identical efficiency of gain. Steers fed a similar protein replacement by ammoniated molasses, gained 0.04 lb. per day less than those getting the urea supplement, with almost identical efficiency of gain. In another test in which ammoniated molasses replaced 1/6 of the protein in the supplement (32% protein), gains were exactly the same as the controls, and feed efficiency nearly the same. In this comparison, steers getting a comparable amount of protein from ammoniated dried citrus pulp, gained within 0.02 lb. per day of the controls on almost the same feed consumption. In the last test, 64 steers in four groups

fed a 24% protein supplement containing Furafeed, supplying 1/5 to 2/5 of the protein, gained from 0.02 to 0.04 lb. more per day than the controls. A combination of Furafeed and ammoniated molasses, each supplying 1/5 of the protein in the supplement, produced 0.08 lb. more gain per day than the controls, with almost identical feed efficiency.

QUANTITATIVE THREONINE REQUIREMENT OF THE WEANLING PIG.

E. T. Mertz, W. M. Beeson and H. D. Jackson, *Purdue University*.

Fifteen crossbred barrows averaging 24.3 lbs. were divided into five lots on the basis of starting weight. All lots received a ration containing 88.0% corn which supplied 0.2% L-threonine to the finished feed. The corn was supplemented with 4.3% minerals, 0.5% liver extract, terramycin·HCl (10 mg./lb. feed), crystalline B_{12} (10 μg./lb. feed), and purified amino acids at the following levels: 0.10% L-arginine·HCl, 0.38% L-histidine HCl·H_2O, 0.70% DL-isoleucine, 0.26%L-leucine, 2.25% DL-lysine·HCl, 0.51% DL-methionine, 0.72% DL-phenylalanine, 0.20% DL-tryptophan, and 0.92% DL-valine. These levels of amino acids were calculated as necessary after microbiological assay of the corn. The ration for Lot I contained no added threonine while the ration for other lots contained from 0.4% DL-threonine (Lot II) to 1.0% DL-threonine (Lot V). Diammonium citrate was added to the rations of Lots I–IV inclusive to equalize the nitrogen content to that of the highest threonine level (Lot V). Rations for all lots contained 13.2% protein. The pigs were fed twice daily according to their appetite; supplementary fat-soluble and water-soluble vitamins were added to the evening feed in sufficient amounts to meet the daily requirement. During the 35 day period on these diets the animals made average daily gains of 0.5 lb./pig on 0.2% L-threonine (Lot I), 1.0 lb./pig on 0.4% L-threonine (Lot II), 0.8 lb./pig on 0.5% L-threonine (Lot III), 1.0 lb./pig on 0.6% L-threonine (Lot IV), and 0.9 lb./pig on 0.7% L-threonine (Lot V). Based on these data and on the assumption that D-threonine is inactive, the L-threonine requirement of the weanling pig does not exceed 0.4% of the ration.

STUDIES ON FAT AND SOLIDS LEVELS AND LENGTH OF FEEDING PERIOD OF SYNTHETIC MILK FOR BABY PIGS.

L. F. Nelson, G. C. Ashton, H. M. Maddock and D. V. Catron, *Iowa Agricultural Experiment Station*.

Five experiments involving over 300 baby pigs have been conducted to study fat levels, solids levels and length of feeding period of synthetic milk under experimental farm conditions. In a preliminary experiment, with disease apparently absent, it was possible to raise 14 pigs which had not received colostrum. After an outbreak of transmissible gastroenteritis, it was impossible to raise pigs without colostrum. Thereafter, the pigs were started on their respective experimental rations, in radiant-heated, concrete-floored pens when 2 or 3 days of age. Without the addition of lard to a vitamin, mineral and antibiotics fortified dried skimmed-milk ration, the pigs did not live. Of the 5, 10, 20 and 30% fat levels studied, the 10% level produced the best growth. A level of 15% solids was superior to 20 or 25% for growth, feed efficiency and physical reconstitution of the milk. The 56-day weights of pigs were not reduced by discontinuing milk feeding at 5 weeks as compared with 7 weeks of age in one experiment. Another experiment indicated that the feeding of the milk ration until the pigs were 4 weeks of age was as satisfactory as feeding it to 3 or 5 weeks.

THE EFFECT OF THREE LEVELS OF MILK FEEDING TO YOUNG CALVES ON THEIR GROWTH RATE AND FEED CONSUMPTION. W. E. Neville, M. E. McCullough, O. E. Sell and D. M. Baird, *Georgia Experiment Station.*

For four months, twelve calves, divided into three equal groups, were hand-fed milk at the rate of 10%, 14% and 18% of their body weight. The rate of milk feeding was adjusted weekly up through six weeks, and held constant at the six week rate of feeding from 7–12 weeks. For the 13–16 week period, each of the six week rates were reduced by 23.8%. The calves, in stalls for the first 12 weeks and then on Bermuda pasture for four weeks, were individually fed good quality lespedeza hay and grain mixture *ad libitum* from 7–12 weeks and were limited to 2.5 lbs. grain daily while on pasture. At six weeks, the daily milk feeding ranged from 9–23 lbs. milk per calf. The average daily gain for the four month period was 1.26, 1.42 and 1.50 lbs. for the 10%, 14% and 18% levels respectively. Differences in growth rate the first six weeks were highly significant ($<.01$) between 10 and 14 and between 10 and 18 but significant ($<.05$) between 10 and 18 only for the entire four month period. Considerable variation together with small numbers of animals appear to have kept differences from being significant between 10 and 14 group for the four month period. A significant negative correlation ($-.55$) existed between 7–12 week hay and grain consumption and 13–16 week dry matter intake of pasture. A highly significant negative correlation ($-.71$) existed between daily milk consumption on pasture and daily dry matter intake of pasture.

"A COMPARISON OF METHODS OF ADMINISTRATION OF PENICILLIN TO SUCKLING PIGS". J. E. Oldfield and O. M. Hale, *Oregon State College.*

Experiences of numerous investigators using antibiotics in rations for weanling pigs, and more recently the market release of a synthetic sows' milk containing an antibiotic, have focussed attention on the importance of providing such materials to pigs at an early age for optimum results. It was determined to investigate the activity of an antibiotic (procaine penicillin G, Merck) when administered to very young suckling pigs by several different methods. Nine litters of Berkshire pigs were used in the experiment, and pigs from each litter were randomly assigned to four groups, one which served as a control. The pigs in the second group received 280 mg. of procaine penicillin G in sesame oil intramuscularly 3 days after birth. Those in the third group received the same dosage of penicillin orally by capsule, while the fourth group were given the same total amount of penicillin divided among four oral doses at weekly intervals. The pigs were weighed at weekly intervals, and at weaning at 8 weeks. Weight gained from birth to weaning averaged 19.8 pounds among the controls; 23.3 pounds for the injected group; 21.5 pounds for those receiving one large oral dose and 20.2 pounds in the group which received the same amount of penicillin divided among four weekly oral doses. The results obtained indicate some advantage for antibiotic supplementation for pigs which are still nursing the sow; moreover they suggest the efficiency of parenteral administration.

FORAGE EXTRACTS WHICH CAUSE BLOAT OR DEATH WHEN ADMINISTERED ORALLY TO SHEEP. A. R. Parsons, Glen Hall, and W. E. Thomas, *University of Kentucky.*

Twelve yearling crossbred wether lambs weighing an average of seventy pounds were dosed orally with the extracts from Ladino clover, alfalfa, birdsfoot trefoil, and Ky. 31 fescue forages. Sixteen, thirty-two, and forty-eight ounce doses of each of the forage extracts were administered to the animals. The

sixteen ounce and higher doses of the birdsfoot trefoil extract were lethal producing death in from nine to thirty minutes after dosing. The symptoms of the animals administered lethal doses of the birdsfoot trefoil suggested cyanide poisoning. Some of the dying animals were given sodium thiosulfate, a cyanide antidote, orally and death was prevented in each of the treated cases. Sixteen ounces of alfalfa or ladino clover extract produced slight bloat while thirty-two ounces of either extract produced excessive bloat in less than one hour. The higher dose levels in both cases produced scours in the experimental animals. Sub-lethal and lethal doses of birdsfoot trefoil and excessive doses of Ky. 31 fescue extracts did not produce a bloated condition. All forage extracts were analyzed for hydrocyanic acid content by the Alkaline-Picrate test. An Evelyn photoelectric colorimeter with a 515 millimicron filter was used to measure the color change in the test solutions.

THE EFFECT OF ADDING VARIOUS LEVELS OF AUREOMYCIN, BACITRACIN, PENICILLIN OR TERRAMYCIN TO THE RATION OF GROWING AND FATTENING SWINE. T. W. Perry and W. M. Beeson, *Purdue University.*

Aureomycin or terramycin were added at various levels to an 18% animal and plant protein ration for pigs which had the following composition: yellow corn 74%, soybean meal 10.26%, fish meal 5.13%, meat scraps 5.13%, cottonseed meal 2.56%, alfalfa meal 2.56%, A and D oil, vitamin B_{12}, riboflavin, niacin, calcium pantothenate, steamed bone meal, limestone and iodized salt. Average daily gains, for each lot of 10 pigs each (initial wt. 60 lb.) were: basal 1.64 lb.; basal plus 1.0 mg. terramycin, 1.68 lb.; basal plus 2.5 mg. terramycin, 1.53 lb.; basal plus 5.0 mg. terramycin, 1.78 lb.; basal plus 7.5 mg. terramycin, 1.90 lb.; basal, 1.74 lb.; basal plus 1.0 mg. aureomycin, 1.49 lb.; basal plus 2.5 mg. aureomycin, 1.73 lb.; basal plus 5.0 mg. aureomycin, 1.74 lb.; basal plus 7.5 mg. aureomycin, 1.96 lb. In a later experiment bacitracin or aureomycin or a 5 to 1 mixture of bacitracin and penicillin was added to diet whose composition is listed above. The average daily gains for each lot of ten pigs, at the end of twelve weeks (started at 40 pounds) follow: basal, 1.28 lb.; basal plus 2.5 mg. bacitracin, 1.16 lb.; basal plus 5.0 mg. bacitracin, 1.30 lb.; basal plus 7.5 mg. bacitracin, 1.19 lb.; basal, 1.24 lb.; basal plus 2.5 mg. aureomycin, 1.26 lb.; basal plus 5.0 mg. aureomycin, 1.38 lb.; basal plus 7.5 mg. aureomycin, 1.36 lb.; basal plus 5.0 mg. mixed antibiotic (5 bacitracin to 1 penicillin), 1.18 lb.; basal plus 7.5 mg. mixed antibiotic, 1.34 lb.

UREA IN RATIONS FOR PREGNANT AND LACTATING EWES. L. S. Pope, W. D. Gallup, and D. C. Read, *Oklahoma Agricultural Experiment Station.*

Urea and cottonseed meal were compared as nitrogen supplements for mature fine-wool ewes during the last 115 days of gestation and the first 42 days of lactation. Three lots of 10 ewes each were used in two consecutive trials. All lots received prairie hay as the roughage (2.0 lbs. per ewe daily). Lot 1 was fed a pelleted mixture of corn, cottonseed meal and molasses containing 10.3% crude protein. Lot 2 was fed the same pellet with 2.1% urea ("Two-Sixty-Two") added to raise the crude protein content to 15.6%. For Lot 3, the pellet contained an increased proportion of cottonseed meal to provide 15.3% crude protein. The pelleted feeds were made equal in energy and phosphorus and fed at the rate of 1.0 lb. per ewe daily during gestation and 2.0 lbs. during lactation. Ewes with twins were given the largest lamb to raise as a single. Average weight gains of the ewes from the start of the experiment to immediately after lambing were −1, +6 and +8 lbs. each for Lots 1, 2 and 3, respectively. In the same

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order, average lamb gains from birth to 42 days were 20.3, 24.3 and 25.1 lbs. These differences, in favor of Lots 2 and 3 over Lot 1, were significant ($P<.01$). Average fleece weights, while not significantly different, were 7.8, 8.6 and 8.9 lbs. for Lots 1, 2 and 3, respectively. There was no significant difference among the lots in the birth weight of the lambs or the weight change of the ewes during lactation. Blood and colostrum urea levels of ewes of Lot 2 were slightly lower than those of Lot 3, while hemoglobin levels were significantly lower ($P<.05$).

COMPARISON OF HIGH-, MEDIUM-HIGH- AND LOW-PROTEIN CORN FOR FATTENING LAMBS. C. V. Ross, U. S. Garrigus, T. S. Hamilton, and E. B. Earley, *University of Illinois.*

Thirty black-faced western lambs were trio fed (equal feed) for 70 days on corn-timothy hay-molasses rations to compare the feeding value of high-, medium-high- and low-protein corn (13.2, 11.03, and 7.72% crude protein). Body gains, wool growth, dressing percentage and carcass grades were compared. Lambs fed both high- and medium-high-protein corn made significantly greater gains and produced significantly more wool than lambs fed low-protein corn. No significant differences were observed between gains or wool produced by lambs on medium-high- (11.03%) and high- (13.2%) protein corn.

SUPPLEMENTING HIGH- AND LOW-PROTEIN CORN FOR GROWING-FATTENING PIGS. C. V. Ross, S. W. Terrill, and D. E. Becker, *University of Illinois.*

Methods of supplementing corn, particularly high-protein corn, were compared in five experiments. In experiment 1 additions of DL-lysine and DL-tryptophan to a high- (11.05%) protein corn-vitamin-mineral basal ration promoted small but significantly greater gains by pigs than those on the basal ration, but less than pigs on the basal ration plus protein supplement. Raising levels of DL-lysine and DL-tryptophan and adding DL-methionine (in phase 2) caused increased daily gains and feed efficiency equal to those of pigs fed the basal ration plus protein supplement. Levels of DL-lysine required to supplement high-protein corn (13.24% protein and 0.3% lysine) were studied in experiments 2 and 3. The addition of 1% DL-lysine was just as efficient as four higher levels tested in experiment 2, while the point of highest efficiency in experiment 3 lay between 0.6% and 1.0% DL-lysine (intercept=0.78%). Additions of 0.2, 0.6, 1.0, 1.4, and 1.8% DL-lysine to low-protein corn (7.65% protein and 0.2% lysine) in experiment 4, resulted in a linear effect with a regression on body weight of 12.5 pounds for each percent DL-lysine. In experiment 5 three supplements designed to furnish needed amino acids to high- (11.05%) protein corn were compared to a standard supplement (soybean oil meal 40%, fish meal 20%, meat and bone scraps 20%, cottonseed meal 10%, and alfalfa meal 10%). All specially designed supplements were significantly more efficient in supplement required per unit of gain than the standard supplement. The composition of the most efficient supplement was blood meal 50% and fish meal 50%.

REPORT ON FEEDING AUREOMYCIN SUPPLEMENT TO MATURE DAIRY BULLS AND LACTATING DAIRY COWS. L. L. Rusoff, M. O. Haq, Cecil Branton, T. E. Patrick, and G. D'Arensbourg, *Louisiana Agricultural Experiment Station.*

Ten mature dairy bulls (4 Guernseys, 4 Jerseys and 2 Holsteins) with low and moderate levels of fertility were used to determine the effect of feeding

an aureomycin supplement (2% level in the grain mixture equivalent to approx. 300 mg. aureomycin daily per animal) on semen production and fertility. A reversal type experiment was run, each period being of 10 weeks duration. The semen characteristics and fertility data were as follows: For the control group—no. of ejaculates, 98 and for the aureomycin group, 110; vol. per ejac. (ml.) 5.50 and 5.33; sperm per ml.$\times 10^6$, 1,514 and 1,485; sperm per ejac.$\times 10^6$, 8,042 and 8,456; percent initial motility, 50.4 and 46.6; motile sperm per ejac.$\times 10^6$, 4,164 and 3,918; first services, 979 and 1,141; non-returns 627 and 773; and percent of 60–90 day non-returns 64 and 67, respectively. Statistical analyses of the data showed no significant differences between treatments. Two comparable groups of 5 lactating Holstein cows each were fed a 15.5% digestible protein grain ration. One group served as a control and the other received an aureomycin supplement (1% level) so that approx. 130 mg. of aureomycin was consumed daily per animal over a period of 60 days. Milk production records for both groups showed no significant difference in the amount of 4% fat-corrected milk. The composition of the milk for butterfat, total solids, solids-not-fat, protein, titratable acidity, pH, ash, Ca and P was very similar for both groups. The bacterial count of the milks also showed no significant difference between the groups. No evidence of any physiological effect was observed in the feeding of aureomycin to the cows or bulls.

EFFECT OF ANTIBIOTICS, ARSANILIC ACID, SURFACTANTS AND SULFAS ON THE GROWTH OF BABY PIGS FED SYNTHETIC DIETS. Harold E. Schendel and B. Connor Johnson, *University of Illinois.*

The growth stimulatory effect of various compounds was measured using baby pigs fed a "synthetic milk" diet. Of the antibiotics studied, aureomycin and terramycin exerted the greatest effect on growth. Penicillin, streptomycin, chloromycetin and No. 802 also stimulated growth while rimocidin failed to produce a significant growth response. Since the addition of various surface activating agents to the ration of chicks has been reported to exert a significant effect on growth (Ely, Science, 114:523, 1951), we attempted to produce a similar response with the baby pig. Under our conditions we have been unable to demonstrate a response of increased growth exerted by the surface activating agents, either alone or as a mixture. We have studied ethomeen C/15 alone and a mixture of ethofat C/15, ethomid C/15, arquad S, aerosol SE, aerosol OS and ultrawet K. Neither of the sulfa drugs used in this study, sulfathalidine and sulfisoxazole (gantrisin) were shown to stimulate the growth of baby pigs. Arsanilic acid did increase the rate of growth significantly.

THE QUANTITATIVE THREONINE REQUIREMENT OF THE SUCKLING PIG. R. F. Sewell, J. K. Loosli, L. A. Maynard, Harold H. Williams, and B. E. Sheffy, *Cornell University.*

Twenty-five 2 to 3-day old Yorkshire pigs were divided into 5 groups and individually fed simulated milk diets in which the protein nitrogen was supplied by isolated soybean "alpha" protein, crystalline amino acids, and ammonium citrate (dibasic). DL-threonine was added to the 5 experimental diets so as to provide the following levels of L-threonine (expressed as percent dry matter): Lot I, 0.36%; Lot II, 0.54%; Lot III, 0.73%; Lot IV, 0.92%; and Lot V, 1.12%. The average daily gain and the kilograms of dry matter required to produce a kilogram of gain for each of the five levels of L-threonine over a 3 weeks experimental period were 8.0, 34.0, 107.0, 137.0, 118.0 grams and 12.33, 4.12, 1.90, 1.54, 1.79 kilograms, respectively. These data indicate that the minimum

level of L-threonine necessary for maximum growth and feed efficiency of suckling pigs fed a diet of this type containing approximately 25.0% protein, is 0.9% of the dry matter of the diet.

THE UTILIZATION OF ELEMENTAL SULFUR AND UREA NITROGEN BY GROWING LAMBS ON A PURIFIED RATION. P. B. Starks, W. H. Hale, U. S. Garrigus, and R. M. Forbes, *University of Illinois.*

To study the utilization of elemental sulfur and urea nitrogen by growing lambs, a ration was formulated that contained .062% sulfur and consisted of the following ingredients: starch 41.4%, corealose 24.5%, wood flock 10.0%, wheat straw 10.0%, mineral mixture 5.0%, corn oil 3.0%, gelatin 2.0% and choline 0.1% plus vitamins A, D, E, thiamin and riboflavin. A second ration was the basal ration plus 3 grams of elemental sulfur per pound of feed and contained 0.705% sulfur. To test these rations, eight lambs were pair-fed equal feed intake. The first lamb in each pair received the basal ration while the second lamb of each pair received the supplemented one. The feeding trial was conducted for 90 days. Nitrogen and sulfur balances were obtained at three periods throughout the trial. The lambs receiving added sulfur retained significantly ($P=<.01$) more of the dietary nitrogen than did the lambs receiving the basal ration. The difference in sulfur retention was significantly ($P=<.01$) in favor of the supplemented lambs. In all four pairs wool growth was in favor of the lambs on the sulfur supplemented ration but was not statistically significant and the nitrogen and sulfur composition of the wool was not altered. The lambs lost weight throughout the trial due to the low feed intake of the basal lambs which determined the feed intake with each pair. The following symptoms were observed in the sulfur deficient lambs: poor appetite, loss of wool, excessive lacrimation, cloudy eyes, profuse salivation, dullness, weakness, emaciation and death. The sulfur supplemented lambs in contrast were strong, alert and had good appetites.

THE RIBOFLAVIN REQUIREMENT OF SWINE FOR REPRODUCTION. J. W. Stevenson, Charles O. Miller, and N. R. Ellis, *U. S. Department of Agriculture.*

In a previous paper, Miller and Ellis, 1951, reported that 0.83 mg. of riboflavin per pound of diet was adequate for growing swine. As an extension of this study, the gilts which had been reared from weaning to breeding age on the four levels continued to receive diets containing 0.55, 0.83, 1.25 and 1.65 mg. of riboflavin per pound. Adequacy of a given riboflavin level was determined by the farrowing and weaning results through two consecutive reproductive cycles. The level of 0.55 mg. of riboflavin per pound of feed already determined to be sub-optimal for growth was inadequate for reproduction. The diet which contained 0.83 mg. of riboflavin per pound appeared to be barely adequate for the gestation period but deficient for optimum lactation. The level of 1.25 mg. of riboflavin per pound of feed gave near optimum results for both gestation and lactation. Although increasing the riboflavin content of the diet from 1.25 mg. to 1.65 mg. per pound gave slightly better results in a few cases, the evidence was not conclusive. Therefore, a level of 1.25 mg. of riboflavin per pound of feed is indicated as the practical minimum recommended allowance for breeding gilts and sows. Swine diets based on commonly used grains, if supplemented to afford the prescribed levels of protein and minerals, will generally be adequate in riboflavin.

THE PANTOTHENIC ACID REQUIREMENT OF THE BABY PIG. S. C. Stothers, R. L. Johnston, J. A. Hoefer, and R. W. Luecke, *Michigan State College.*

Three separate experiments were carried out in this study of the pantothenic acid requirement of the baby pig. The pigs were started at 2–3 days of age and were fed in groups of 2–3 pigs per lot. Thirty-five pigs were in the three experiments and each trial lasted from 20–32 days. The synthetic milk diet was made up as follows: casein (vitamin-free) 30%, cerelose 37.4%, lard 26.6%, mineral salts 6%. A vitamin mix containing all the required vitamins except pantothenic acid was added after the milk was homogenized. The milk was made up to a 15.4% solids basis. A calcium pantothenate solution was added to the milk at the desired levels for each lot. The growth performance of the pigs in these experiments would indicate that the pantothenic acid requirement of the baby pig is between 1.0 and 2.0 mg. per 100 gm. of solids. The pigs with no pantothenic acid added to their milk developed a diarrhea within two weeks which persisted until the end of the trial. Locomotor incoordination developed within three to four weeks. Postmortem findings in the deficient pigs indicated a marked congestion and some hemorrhage throughout the gut, but more especially in the cecum and colon. Frequently clumps of fecal material would be found adhering to the intestinal mucosa.

STARTER RATIONS FOR CREEP-FED PIGS. S. W. Terrill, R. J. Meade, T. S. Nelson, and D. E. Becker, *University of Illinois.*

Eight experiments involving 227 sows and 1,540 suckling pigs were conducted to study various aspects of creep-feeding nursing pigs from 2 to 8 weeks of age. All tests were conducted on pasture except one in which creep-fed pigs in drylot were weaned at 5, 6 and 7 weeks of age and continued on a mixed pig starter ration to 8 weeks of age. Average daily gains from 2 to 8 weeks were 0.46, 0.50 and 0.57 lbs. respectively. In a study of the value of creep-feeding a palatable pelleted pig starter ration when small groups of sows and litters were self-fed shelled corn and supplement on rye pasture, the daily gains of creep and no creep pigs were 0.61 and 0.50 lbs. respectively. The addition of antibiotics to the pig starter ration was not effective in increasing daily gains of suckling pigs in two trials. Daily gains for pigs creep-fed starter rations containing 14, 17, 20 and 23% crude protein were 0.55, 0.62, 0.62 and 0.61 respectively. Hulled oats and pig supplement, modified artificial milk in dry form, and a mixed pig starter ration were equally effective in promoting daily gains, whereas a high-efficiency broiler ration was less palatable and gains were slower. In a palatability trial, the feeds consumed in greatest quantity included hulled oats, a mixed pig starter ration, and combinations of either rolled oats or dried skim milk with a molasses concentrate.

THE UTILIZATION OF AMMONIATED INDUSTRIAL BY-PRODUCTS AND UREA BY SHEEP. A. D. Tillman and R. W. Swift, *The Pennsylvania State College.*

When ammoniated condensed distillers molasses solubles, ammoniated cane molasses and urea (262) were mixed with cerelose and a basal mixture composed of natural feedstuffs in such way that the total rations were iso-caloric and iso-nitrogenous and compared to soybean oil meal fed the same way to growing sheep, the following results were obtained: (1) The ration constituents of the urea-containing ration were digested as well as those of the soybean oil meal ration. (2) The ammoniated products decreased the digestibility of all ration

constituents except ether extract. The decrease was greatest in the case of nitrogen. (3) The sheep receiving either urea or soybean oil meal in their rations stored more nitrogen in their bodies than the sheep receiving the rations containing the ammoniated products. (4) The soybean oil meal ration contained the highest level of metabolizable energy and was followed in order by the urea, ammoniated CDMs and ammoniated cane molasses rations. (5) The urea ration promoted the lowest storage of carbon and body fat. (6) There was no loss of nitrogen from the rations containing urea or either ammoniated products when they were stored for a period of 120 days. (7) There was good agreement between the directly determined and calculated heat production values.

B VITAMIN DEFICIENCIES IN RATIONS FOR WEANLING PIGS. L. F. Tribble, J. F. Lasley, and A. G. Hogan, *University of Missouri.*

Twelve trials, involving 240 pigs, have been completed at the Missouri Experiment Station to determine the effect of adding the B-complex vitamins—riboflavin, pantothenic acid, and nicotinic acid—to corn and soybean oil meal and corn and tankage rations for weanling pigs in dry lot. The basal ration also contained 0.5 percent of cod liver oil and 2.0 percent of minerals. Crystalline vitamins were added to supply the following in mg. per pound of feed: riboflavin 3.8, pantothenic acid 12.5, and nicotinic acid 18.5. The weanling pigs used weighed between 35 and 60 pounds at the start of the trials and were fed in concrete pens for approximately three months. The pigs that received the B-complex vitamins, in an average of all trials, made an average daily gain of 1.38 pounds as compared to 1.22 pounds for the pigs on the basal rations. In seven trials, the pigs that received the corn and soybean oil meal rations plus the three vitamins made an average daily gain of 1.40 pounds as compared to 1.29 pounds for the pigs on the basal rations; however, there was no difference in efficiency of gains. The corn and tankage ration was even more deficient in one or more of the three vitamins as the pigs that received the B-complex vitamins gained 0.22 pounds per head per day more and required 38 pounds less feed per 100 pounds gain than those on the basal rations in five trials.

PARASITISM IN BEEF YEARLINGS AS RELATED TO FORAGE CONSUMPTION AND LEVELS OF PROTEIN FEEDING. Halsey H. Vegors, D. M. Baird, O. E. Sell, and T. B. Stewart, *U. S. Department of Agriculture and Georgia Experiment Station.*

To determine factors which may affect internal parasitism and rate of gain of yearling beeves as related to forage consumption and levels of protein feeding, the following treatments were instituted: (1) dry lot—no grass growth allowed; (2) semi-dry lot—a limited amount of Abruzzi rye available for the pick-up of larvae; and (3) winter pasture—composed mostly of Abruzzi rye with some rye grass and crimson clover. Two levels of protein feeding, 20% above versus 20% below NRC requirements, but equated for energy, were given steers in each of the above three treatments. Average daily gain was highest (2.31) on the pastures, second highest (1.69) on semi-dry lots, and lowest (1.51) on dry lots. The most prevalent species of worms encountered were the stomach worms, *Haemonchus contortus, Ostertagia ostertagi* and *Trichostrongylus axei,* and the intestinal worms, *Cooperia punctata* and *C. oncophora.* The average number of worms recovered from steers at slaughter was as follows: Dry lots, 13,324; semi-dry lots, 16,364; and pastures, 11,319. There appeared to be a difference in availability or viability of parasites between the above treatments since the average number of larval worms was 0, 538, and 3,713, respectively.

It was also noted that only one-fourth as many larval worms were recovered from steers on high protein as was recovered from steers on low protein.

DETERMINATION OF ENDOGENOUS CALCIUM IN CATTLE USING CA^{45}. W. J. Visek, R. A. Monroe, E. W. Swanson, and C. L. Comar, *University of Tennessee—A. E. C. Agricultural Research Program.*

Endogenous calcium was determined in 2 lactating cows and in 2 growing steers. With the steers a reversal procedure was used to demonstrate the effects of dietary calcium level. Ca^{45} was injected daily for 10 days, and for an equal period thereafter radio and chemical assays were made on the blood, feces and urine. Since steady state conditions were obtained, the actual fecal calcium coming from body stores was calculated from the ratio of blood and fecal specific activities. A 306 kg. cow on a normal diet showed an endogenous fecal calcium excretion of 4.2 g. daily, while a 376 kg. cow receiving the normal ration plus 300 g. of steamed bone meal daily showed a daily value of 6.7 g. A 248 kg. steer on a normal ration had an endogenous fecal calcium excretion of 3.4 g. daily, as compared to 3.1 g. when the calcium intake was increased 32 g. daily with $CaCO_3$. Respective daily values for a 255 kg. steer were 4.5 g. and 4.9 g. It appears that the endogenous fecal calcium was independent of the dietary calcium and phosphorus level fed, and that the differences were probably due to animal variation. Urinary mineral excretions were within the normal range. This simple technique appears particularly promising because it allows for the determination of endogenous fecal calcium in animals differing in body size, physiological state and dietary calcium intake.

EFFECT OF ANTIBIOTIC FEEDING ON BLOOD GLUCOSE LEVELS OF YOUNG DAIRY CATTLE. H. Voelker, N. L. Jacobson, and R. S. Allen, *Iowa State College.*

Studies involving approximately 1,500 blood samples from 135 young dairy cattle indicated that the blood glucose values of animals fed 200–240 mg. aureomycin hydrochloride (in Aurofac 2A) per calf daily for a considerable period of time were not significantly different from those of animals receiving no antibiotic. Moreover, no apparent changes in blood glucose values occurred subsequent to the addition of 200 mg. aureomycin per calf daily to the diets of calves not fed aureomycin previously. Conversely, the administration of a 50% glucose solution (150 gm. glucose per calf in one trial and 2.25 gm. per pound body weight in other trials) resulted in significantly greater increases at 1, 2 and 3 hours after glucose administration in aureomycin-fed calves than in calves fed no antibiotic. Average blood glucose values expressed as mg. per 100 ml. blood at 0, 1, 2, 3 and 6 hours after glucose administration were 71, 151, 124, 122 and 73, respectively, for calves fed aureomycin and 68, 133, 114, 101 and 70, respectively, for the controls. Differences were observed both among calves which were not fasted and among calves which were fasted prior to glucose administration but the differences were of lesser magnitude in the latter instance. Higher glucose tolerance curves also were noted in calves fed penicillin and terramycin.

IN VIVO (DAIRY CALVES) AND *IN VITRO* STUDIES WITH SURFACE ACTIVE AGENTS. H. Voelker, R. S. Allen, N. L. Jacobson, and J. T. Blake, *Iowa State College.*

Twenty-six dairy calves (Holsteins, Brown Swiss and Guernseys) averaging 13 weeks of age were divided into two groups and were fed hay free-choice

and a concentrate mixture limited to a maximum of 6 pounds per calf daily. Each calf in one group also received a detergent at the rate of 2 pounds per ton of concentrate mixture. Five detergents (non-ionic, cationic and anionic types) were employed, three being fed to two calves each and the two being fed to four calves each. No significant differences in rate of weight gain over a period of 13 weeks was apparent; the average daily gain for calves in the detergent group was 1.56 pounds compared to 1.57 in the control group. Moreover, there were no significant differences between the groups in changes in body measurements (height at withers, chest circumference and barrel circumference) and in blood plasma fat levels as determined by the "Allen" method. The number of calf-days scouring was 110 for the detergent group and 43 for the control group. Hay consumptions for the two groups were similar whereas the detergent-fed calves consumed somewhat less concentrates during the early part of the experiment. *In vitro* studies revealed that several detergents, penicillin and rimocidin markedly reduced the surface tension of distilled water and of fresh rumen fluid (when added at the rate of 5 mg. or more per 100 ml. fluid), whereas aureomycin and terramycin had no appreciable effect. Moreover, feeding 240 mg. of aureomycin daily to calves approximately 14 months of age had no significant effect on the surface tension of the rumen fluid.

THE METABOLISM OF INTRAVENOUSLY ADMINISTERED CAROTENE IN THE DAIRY CALF. R. G. Warner and L. A. Maynard, *Cornell University*.

Two investigations were conducted to determine whether parenterally administered carotene could be utilized as a precursor of vitamin A by dairy calves. Four, 300 lb. Holstein bull calves were depleted of their vitamin A reserves until distinct deficiency symptoms were apparent. Two calves received 40 daily intravenous injections of 5.4 mg. (8,900 I.U.) of carotene while two control calves received injections of 0.95 mg. (3,000 I.U.) of vitamin A alcohol per 100 lbs. body weight respectively. Injection mixtures consisted of a 10% coconut oil in water emulsion stabilized with 2% of intravenous gelatin. No beneficial effects were noted from the carotene injections. Those receiving vitamin A improved noticeably. In contrast to these results, however, aqueous colloidal carotene proved beneficial in a second trial. Six, 300 lb. Holstein calves were depleted until their plasma vitamin A levels fell below 4.0 μg. percent for two consecutive weeks. They received six daily intravenous injections of an aqueous colloidal suspension of carotene at the rate of 30 mg. per 100 lbs. of body weight. A statistically significant ($P<0.05$) increase in plasma carotene and vitamin A was observed as estimated by three independent analytical procedures. No increases resulted when control injections were made. An ultraviolet examination of two of the saponified, chromatographed, post-injection, plasma extracts showed typical vitamin A absorption curves. Examination of similarly treated pre-injection extracts revealed no such characteristics. If these experimental conditions have approached the normal, the results lend support to the thesis that plasma carotene can serve as a source of vitamin A for dairy calves.

STUDIES ON THE NUTRITIVE VALUE FOR LAMBS OF ALFALFA HAY GROWN ON A LOW SULFUR SOIL. W. C. Weir and V. V. Rendig, *University of California*.

Two lamb feeding tests involving 32 and 48 lambs were made to determine the nutritive value of alfalfa hay produced on two soil types both unfertilized and fertilized with 400 pounds of single superphosphate per acre. Yield responses were obtained on one soil (Delhi) while none were obtained on the other

(Hanford). Small plot tests with gypsum showed that the response was to sulfur. In the first trial the inorganic sulur of both Hanford hays was 0.22% while for the Delhi fertilized it was 0.12 to 0.15% and for the Delhi unfertilized 0.08 to 0.12%. The lambs fed the Hanford hay gained significantly more than the lambs fed the Delhi unfertilized hay. The lamb blood serum sulfate increased on the Hanford hay and decreased markedly on the Delhi unfertilized hay. In the second trial methionine or urea was added to the unfertilized Delhi hay to bring the sulfur or nitrogen respectively up to the levels found in the Hanford hay. The lambs receiving methionine gained significantly more than the lambs receiving the urea with the lambs receiving the unsupplemented hay intermediate. The blood serum sulfate of the methionine-fed lambs was similar to that of the lambs fed the Hanford hay while the lambs supplemented with urea had even lower values than the lambs fed the unsupplemented Delhi hay. The relationship of sulfur intake to growth of lambs is not conclusive. Blood serum inorganic sulfate reflects the sulfur intake in the feed and appears to be influenced by the nitrogen:sulfur ratio.

THE EFFECT OF QUALITY AND QUANTITY OF PROTEIN UPON THE LAMB AND WOOL PRODUCTION OF MATURE RANGE EWES. F. Whiting and S. B. Slen, *Dominion Experimental Station.*

Six groups of 16 mature range ewes were fed, individually, pelleted isocaloric rations containing 6 different sources of nitrogen—linseed oil meal, field peas, dehydrated alfalfa, lactalbumin, urea, and urea plus inorganic sulfur. The rations, fed from 3 weeks before breeding until 6 weeks before lambing, contained on a dry matter basis approximately 7.8% total protein (less than 50% of which was contributed by the ingredients in the basal ration) and that fed during the latter part of pregnancy and during lactation contained approximately 11% protein (less than 35% of which was contributed by the ingredients in the basal ration). Three similar groups of ewes were fed rations in which the amount of protein (linseed oil meal) was varied. One group received 7.8% total protein until 6 weeks before lambing and was then increased to 14%, a second received 11%, and a third 14% during the entire experimental period (10 months). There were no significant differences in wool production between the 6 groups receiving the different types of protein with the exception that the "urea plus sulfur" group produced less wool. This could be accounted for in lowered feed consumption by this group. The groups that received the higher levels of protein produced slightly more wool. There were no significant differences in the birth weights of lambs as influenced by quality or quantity of protein. At 6 weeks of age the lambs from the ewes receiving lactalbumin and dehydrated alfalfa were somewhat heavier than those from ewes receiving protein from other sources. Quantity of protein in the ration of the ewes did not influence lamb growth to 6 weeks of age. There were no significant differences in milk composition (fat, protein, N.P.N., or sulfur) as influenced by quality or quantity of protein.

AUREOMYCIN IN BABY PIG MILKS AND STARTERS. W. L. Williams, B. D. Owen, R. F. Elliott and T. H. Jukes, *Lederle Laboratories.*

Experiments have been conducted to test the value of aureomycin supplements in sows milk substitutes and creep feeds. The practicality of several different basic ingredients in the formulation of milk replacers has also been investigated, for the purpose of developing a simplified program, using milk substitutes and pig starters, which can be recommended for field use. Pigs one week of

age, were separated from their dams and allotted to groups of ten each on a littermate basis, with due regard to sex and vigor. The pig starters, in pelleted form, were self fed in conjunction with the milk substitutes. It was found that aureomycin supplementation of a pig starter and a milk replacer based on dried skim and dried whole milk resulted in an average daily gain of 0.79 pounds during a seven week feeding period as compared to 0.48 pounds for the control lot. The value of a combination of a nonionic and a cationic surface active compound in the milk replacer and in the pig starter was also studied in this trial. No growth response was obtained. In another experiment it was found that a milk replacer composed of dried skim milk, lard and lecithin, supplemented with minerals, vitamins and aureomycin could be successfully employed. The use of fish meal and finely ground feeding oatmeal to replace part of the milk solids was investigated.

Pasture, Forage and Range Section

C. S. Hobbs, *Chairman*

CRITERIA FOR THE EVALUATION OF PASTURES WITH BEEF COWS AND THEIR CALVES. D. M. Baird and O. E. Sell, *Georgia Experiment Station.*

There are no standardized methods for evaluating brood cow test rations. To evaluate three winter pastures more fully (fescue, crimson clover and a temporary mixture of rye, ryegrass and crimson clover) and a dry lot ration with brood cows, the following measures were used: (a) cow gains, (b) calf gains, (c) forage intake by the chromic oxide method, (d) forage digestibility by the chromogen method, (e) level of milk production and (f) agronomic estimates of apparent forage consumption. Using these methods the temporary pasture was superior followed closely by crimson clover. Fescue pasture and dry lot feeding were decidedly inferior. Fescue gave the longest grazing season. Average daily gains for cows ranged from —.38 lbs. in the dry lot to 1.27 lbs. on temporary pasture while for the calves the range was from 1.00 to 1.93 lbs. for the same groups. Daily dry matter intake was about 12 lb. greater and the forage was seven percent higher in digestibility on the temporary and clover pastures than on fescue pasture. Milk production ranged from 3 to 35 lbs. per day and was affected by the quality of pasture or ration, lactation stage and cow individuality. Rate of calf gains was correlated with rate of milk production of dams. All pasture feeding cost more than dry lot feeding when performance of cows and calves are not considered. A combination of evaluation methods provides more complete information than any one method by itself. Cow weight loss due to calving while on experiment complicates the use of cow weight changes as a measure of a pasture or ration.

SODIUM METABISULFITE AS A PRESERVATIVE FOR GRASS SILAGE. J. W. Bratzler, R. L. Cowan, and R. W. Swift, *The Pennsylvania State College.*

Preliminary experiments were conducted during the summer of 1951 to investigate the use of a concentrated water solution of sodium metabisulfite ($Na_2S_2O_5$) as a preservative for grass silage. In every case the silages preserved with sodium metabisulfite kept at least as well as comparable materials treated

with SO_2 gas at equivalent levels and much better than untreated control samples. More extensive experiments were conducted this year to determine the efficacy of sodium metabisulfite as a preservative for grass silage under conditions approaching those found in general farm practice. Seven small, wooden silos were used. Three, with dimensions of 5′x 24′ were filled with first-cutting orchard grass. The treatments for the unwilted forage were: control or no preservative, 8 pounds of $Na_2S_2O_5$/ton, and 76 pounds of molasses/ton. The remaining four silos, with dimensions of 5′x 20′, were filled with first-cutting alfalfa mixed with some brome grass. The treatments for the unwilted forage were: control or no preservative, 8 pounds of $Na_2S_2O_5$/ton, 11 pounds of $Na_2S_2O_5$/ton, and 67 pounds of molasses/ton. The sodium metabisulfite was added in the powder form to the chopped forage as it was blown into the silo. A fertilizer attachment for a corn planter was modified in such a way that a constant rate of application could be made. Silage samples obtained after two months of storage indicate that the silages preserved with sodium metabisulfite have retained more of the color of the original forage than either that preserved with molasses or the control.

MAXIMUM USE OF ROUGHAGE AND PASTURE IN PRODUCING CHOICE TWO YEAR OLD STEERS. A. J. Dyer, *University of Missouri.*

Four lots of 10 yearling steers each were used to study further the maximum use of roughage and pasture to produce choice fat two year old steers. The test had three phases e.g., wintering, grazing and fattening in dry lot. Winter rations and how they affected gains from pasture were studied; fescue-ladino mixture was compared with wheat-lespedeza combination as to gain, carrying capacity, finish attained, bloat incidence; total feed required to finish all steers to choice were secured; carcass data were obtained. Corn silage and Korean lespedeza hay produced 1.5 pounds average daily gain (202 total) compared with .1 pound (16 total) from bluegrass pasture and lespedeza hay fed at the same rate in both cases. All had steamed bonemeal and salt. In the grazing phase, cattle gained 42% faster on wheat-lespedeza than on fescue-ladino, the net difference being 77 pounds per head and one slaughter grade advantage. Thin cattle (bluegrass) on fescue-ladino gained 43% faster than fleshy steers (silage, hay) thereon, but did not overcome the weight difference resulting from winter treatment. Fescue-ladino had the greater carrying capacity and high incidence of bloat. Access to bluegrass reduced the incidence of bloat. To reach choice grade, 10.7 bushels corn were required for the "wheat-lespedeza" cattle, 25.4 for the "fescue-ladino" cattle and 37.7 bushels for the cattle wintered on bluegrass and grazed on fescue-ladino. A winter gain of 1½ pounds daily, pasture that produced finish, and a short full-feeding period in dry lot was best.

FORAGE MANGANESE AS A POSSIBLE FACTOR AFFECTING CALCIUM AND PHOSPHORUS METABOLISM OF RANGE BEEF CATTLE. Willis D. Gallup, J. A. Nance, A. B. Nelson, and A. E. Darlow, *Oklahoma Agricultural Experiment Station.*

During a 4-year study in southeastern Oklahoma, Hereford cows that were grazed on native grass in the summer and fed the locally produced native grass hay supplemented with protein in the winter developed severe phosphorus deficiency unless a mineral phosphorus supplement was supplied. Under similar conditions of management, cattle in the north-central part of the state did not require a phosphorus supplement. The grass in the southeastern area contained slightly less phosphorus and from 5 to 10 times as much manganese as that in the north-central. To determine whether high manganese intake might be a

contributory cause of phosphorus deficiency, mineral balances were conducted with steer calves fed rations supplemented with increasing amounts of manganese sulfate. The daily rations supplied about 7.7 gm. of Ca, 14.5 gm. of P and O, 250, 500, 1,000, and 2,000 p.p.m. of added manganese. Phosphorus excretion in the feces increased at all levels of increased manganese intake; calcium excretion increased only at the two highest levels. Calcium and phosphorus balances, determined at manganese intake levels of 0, 250 and 500 p.p.m. were positive. Plasma calcium and phosphorus values were unaffected by manganese intake.

MAGNITUDES OF EXPERIMENTAL ERRORS IN GRAZING TRIALS. H. L. Lucas, *N. C. State College.*

Estimates of experimental errors have been obtained for grazing trials on humid region pastures with growing and fattening cattle. "Put-and-take" stocking was used in all studies. For seasons of 16–26 weeks in length, *animal days* per acre and *T.D.N.* consumption per acre computed from body weight and gain show small errors. *Daily gain* shows large errors with *gain per acre* intermediate. Expressed as coefficients of variation, typical errors were: On 1-acre pastures, *TDN,* 11%; *animal days,* 12%; *daily gain,* 20%; *gain per acre,* 16%; on 5-acre pastures, *TDN,* 7%; *animal days,* 8%; *daily gain,* 12%; *gain per acre,* 9%. Errors for shorter seasons are higher. For TDN with 1-acre pastures, results were: 2-week periods, 42%; 4-week periods, 25%, and 6-week periods, 19%. More pastures per treatment are required for a given precision with 1-acre pastures, but only 50–60% as much land and 50–60% as many animals are required as when using 5-acre pastures. Since fencing and labor costs are about the same in the two cases, the smaller pastures are more efficient. Because carrying capacity may vary considerably, it is advisable to speak of pasture size in terms of animals carried instead of acreage. Pastures that will carry 1–3 animals appear to be of optimum size.

METHODS OF COMPUTING RESULTS OF GRAZING TRIALS. H. L. Lucas, *N. C. State College.*

Results of grazing trials with growing and fattening animals are usually expressed as *animal days* per acre, *daily gain* per head and *gain per acre.* Under "put-and-take" stocking, there arise difficulties in computing and interpreting these measures. It is common (Method I) to report observed *animal days,* observed *gain per acre* and *daily gain* computed as *gain per acre/animal days.* Another method (Method II) is to compute *daily gain* only from the animals on pasture all season ("testers") and to obtain *gain per acre* as *tester daily gain*×*animal days.* Another method has been developed (Method III) which is as follows: Effective TDN consumption per acre (ETDN) is estimated from the weights and gains of all animals. Average daily effective TDN consumption of the "testers" (etdn) is next estimated. *Tester animal days* is computed as *ETDN/etdn. Daily gain* is computed from the "testers" only, and finally *gain per acre* is obtained as *tester animals days*×*tester daily gain.* Special advantages of Method III are (1) estimates of *animal days, daily gain* and *gain per acre* can be obtained separately for each of several kinds of "testers" grazing together on the same pasture and (2) uniformity of animals is required only for the "testers." Errors in the coefficients for converting gain and weight to TDN can have large effects on *ETDN* and *etdn,* but their effects on *animal days* and *gain per acre* will usually be negligible.

SOME FACTORS INVOLVED IN STUDIES ON THE NUTRITIVE VALUE OF PASTURE FORAGES. Marshall E. McCullough and O. E. Sell, *Georgia Experiment Station.*

When the animal complex is united with the plant complex in attempts to evaluate the feeding value of pasture forages for dairy cattle, the normal animal and plant variations are elevated by the combination of the two. This experiment measured in part the degree and intensity of these variations. The principal variables encountered were pasture forage variation, response of animals to supplementary feeds, and techniques employed. Pasture forage varied from 10–28% in protein content, 56–85% in protein digestibility, and 56–80% in dry matter digestibility. Adding hay to the ration gave a 10% increase in persistency of 4% FCM production on fescue forage but no increase on a mixture of oats, ryegrass, and crimson clover during February. During the month of April, hay or beet pulp gave equal milk production on fescue while hay averaged 20% superior production on the temporary pasture mixture. The feeding of grain alone gave highly variable results during both periods. Daily intake of dry matter was determined by use of indicator techniques, cage and mower strip clippings, calculated T.D.N. from animal performance, and cow days of grazing. Average daily intake of T.D.N. for all pastures during the season by each method was (1) calculated T.D.N., 10 lb. per day, (2) cage and mower strip, 11 lb. per day, (3) indicator techniques, 12.4 lb. per day, and (4) standard-cow-day, 16 lb. per day.

WINTER PASTURE COMPARED TO SILAGE OR HAY FOR FATTENING OR WINTERING BEEF CALVES. R. P. Moorman, C. S. Hobbs, H. R. Duncan, Hugh Felts, E. J. Chapman, Ben Hazlewood, J. H. Carrier, and J. B. McLaren, *University of Tennessee.*

A study of the value of winter pasture for calves was the basis of tests initiated in 1949 at four locations by the Agricultural Experiment Station. Winter pasture was seeded in August and September in fields which would carry cattle during wet weather, to insure continuous grazing. The three seasons covered in this report represent one of the best and one of the poorest pasture seasons experienced in recent years. The calves weighed about 450 pounds at the start of the test in December, grading Good to High Good in type and Commercial to Good in condition. Rations varied from silage, hay, and five pounds of concentrate in the barn to winter pasture and hay. With the exception of one test, at the West Tennessee Experiment Station, cattle were sold on the May and June slaughter market. Winter pasture should be seeded early, so maximum growth is obtained before cold weather. In general there is little growth during December, January and February. Winter pasture must be on land that will carry cattle during wet weather. A minimum of shelter was needed for calves on winter pasture. In most instances, the initial and final slaughter grades were similar. Thus, it may be that calves in higher condition will be more desirable when they are to be sold on the spring slaughter market. Carcasses produced under this system have ranged from Commercial to Choice, and have been well received by Tennessee packers. A good margin was obtained in the selling of these calves but they could have sold for $2 to $7 per cwt. less than purchase price and still broke even on feeding operations. Under conditions of this experiment, all systems involved point to a way that a farmer who can get some extra feed can handle his good beef-type calves to increase his returns over selling them at weaning

time. This is provided he raises good beef-type calves with enough quality and breeding to make good gains after weaning and to grade high in the beef.

RELATIVE VALUE OF SUPPLEMENTS OF VARYING PROTEIN CONTENT FOR WINTERING HEIFER CALVES. A. B. Nelson, R. MacVicar, J. P. Fontenot, and A. E. Darlow, *Oklahoma Agricultural Experiment Station.*

Grade Hereford, weanling, heifer calves (186 head) were fed during the winter prairie hay and one pound per head per day of a pelleted supplement composed of either corn and cottonseed meal or cottonseed meal alone and containing either 20, 30 or 40 percent protein. Average change in weight during winter period (3 years) was: —8 pounds, 41, and 85, respectively. Winter gains were directly proportional, gains during the subsequent summer grazing period on native grass pastures inversely proportional, and gains year-long directly proportional to the protein concentration of the winter supplement. During a single season, two groups of heifers were allowed to graze native grass pastures and fed one pound per head per day of a supplement containing either 20 or 40 percent protein. In two subsequent years, four groups of heifers were fed either one or two pounds per head per day of either 20 or 40 percent protein supplement. Average change in weight during the winter grazing period was: 1 pound of 20 percent protein supplement, —25 pounds; 1 of 40 percent, 10; 2 of 20 percent, 16; 2 of 40 percent, 35. As was found in the experiment in which hay was fed during the winter, gains during the winter phase were again directly proportional and subsequent summer gains inversely proportional to the protein content of the supplement at the same level of intake. Slightly greater yearly gains resulted from the feeding of 20 percent protein supplement to heifers grazing year-long. Nitrogen balance and digestion studies have been conducted with steers fed prairie hay and supplements of 20, 30 and 40 percent protein content.

ALFALFA-ORCHARDGRASS GRAZING FOR MILK PRODUCTION. A. G. Van Horn, W. M. Whitaker, and R. H. Lush, *University of Tennessee.*

A rotational grazing experiment was started in 1949 to determine if alfalfa might be satisfactorily maintained in a mixture with only a 20-day interval for recovery, under either deferred or all season grazing in Middle Tennessee. An attempt was made to equalize soil and seeding conditions in an 18 acre field, divided into four fields, each further subdivided into three small fields for grazing 10 days. Limited grain and hay was fed to Jersey cows used and each field moderately stocked to avoid close-grazing. Two of the fields were used for deferred rotational grazing after cutting an average of 2,733 pounds of hay per acre in May. Rainfall and results have been quite variable for two years, with a third year to be presented. The first two years milk yields and returns per acre have been about 9 percent higher from all-season than delayed grazing but the latter system has resulted in a much better stand of alfalfa after three years and has given a greater proportion of grazing in the late summer when needed most. The all-season grazing averaged 6,009 pounds of milk per acre as compared to 3,983 pounds milk plus 2,767 pounds of hay per acre from deferred grazing. All of the ladino clover and a small percent of the orchardgrass died during the second year due to extreme drouth conditions. Little difficulty with bloat was experienced when hay was fed free choice in the barn. Chemical analyses of vegetation grazed showed little variation for plots or season but a rather high protein, medium ash and low lignin content.

Physiology Section

Joseph Meites, *Chairman*

FERTILITY OF BULL SEMEN DILUTED WITH BOILED, HOMOGENIZED MILK AND BOILED SKIM MILK. J. O. Almquist and D. L. Thacker, *The Pennsylvania State College.*

Using the split ejaculate technique, a series of fertility tests were conducted to study boiled milk as a bovine semen diluter. In each trial, pasteurized milk was previously heated to 92°–95° C. for 10 minutes and the control diluter was egg yolk-citrate (1:1) containing 1,000 units each of penicillin and streptomycin per ml. Fertility was based on 60- to 90-day percent non-returns for first service cows. In the first trial involving 12 bulls and 6,670 inseminations, semen diluted in boiled, homogenized milk with antibiotics averaged 4% more ($P \leqq 0.05$) than the same milk without antibiotics and 7% higher ($P \leqq 0.01$) than the control. Based on selection prior to the experiment, increases in the 6 low fertility bulls accounted for the major portion of the improvement obtained with milk plus antibiotics as compared to the control. In a second experiment, it was found that addition of one percent cooking cornstarch would increase the viscosity of milk so that it was easier to control during the insemination process. Cornstarch was not toxic to spermatozoan motility survival and did not affect fertility significantly on the basis of 5,104 inseminations. Data from 9,395 cows in a third field trial showed that boiled, pasteurized skim milk with antibiotics plus cornstarch gave the same fertility results as the yolk-citrate control. An insignificant difference of 3% in favor of the control was obtained using boiled, homogenized milk together with antibiotics and cornstarch. These results show that previously boiled, homogenized milk or skim milk containing antibiotics and cornstarch can be used as satisfactory diluters for bovine semen.

RAM SEMEN AS AFFECTED BY SEASON. A. L. Badreldin, M. M. Oloufa, and Y. H. Darwish, *Cairo University.*

Sheep in Egypt are usually mated during May and June. To study the effect of season on semen quality, 12 Egyptian (fat-tailed) rams were used. They ranged in age from 2 to 3 years. One ejaculate was collected from each ram every 10 days for 12 months. Semen characteristics studied were: volume, motility, concentration, percentage of abnormal sperm and percentage of live sperm in fresh semen and in semen stored for 48 hours at 40° F. The effect of season on semen quality was statistically highly significant. Most semen characteristics studied showed that the quality of semen was highest in spring (March, April and May), followed by the fall, then summer with winter last. Apparently there was no "summer sterility" under the present experimental conditions. This was probably due to the great difference in environmental temperature between day and night during summer. Since semen quality was at its lowest level in winter (December, January and February), which had the mildest weather with green feed most abundant, it is suggested that light rather than temperature was the main factor in affecting the fertility of rams in winter under the conditions of this experiment.

THE RELATION OF O_2 UPTAKE TO RESPIRATORY QUOTIENTS OF BULL SEMEN IN CITRATE-GLUCOSE BUFFER. F. N. Baker, N. L. VanDenmark, G. W. Salisbury, and A. VanTienhoven, *University of Illinois.*

Balance studies including O_2 uptake, CO_2 production, reducing substances lost, and lactic acid gained were carried out on 19 samples of bull semen in citrate-glucose buffer. The mean oxygen consumption was .63 micromoles per 10^8 sperm per hour; the mean CO_2 production was .52 micromoles per 10^8 sperm per hour. Total reducing substances lost (calculated as hexose) and lactic acid gained averaged .44 and .39 micromoles per 10^8 sperm per hour respectively. Of the reducing substances lost .09, .19, and .16 micromoles per 10^8 sperm per hour were oxidized to CO_2, converted to lactic acid, and unaccounted for respectively. Thus only 64% of the reducing substances lost could be accounted for. The mean R.Q. was .81. The R.Q. was found to be positively correlated ($r=.725$, significant at .01 level) with O_2 uptake. This suggests that hexose forms a higher proportion of the substrates oxidized by samples having high respiratory activity than is the case with samples having low respiratory activity.

OCCURRENCE OF ESTRUS IN SOWS FOLLOWING PARTURITION. L. N. Baker, H. L. Woehling, L. E. Casida, and R. H. Grummer, *University of Wisconsin.*

The occurrence and fertility of estrus following parturition were studied in an experiment on 29 sows in which one group suckled their pigs for two days and were allowed to eat the afterbirth, and another group had their pigs removed at birth and were not allowed to eat the afterbirth. No significant differences between the two groups were observed with respect to (1) the incidence of "post-partum" or "true" heat, (2) the interval from farrowing to the onset of the heats, (3) the length of these heats, or (4) the fertilization rate. The combined data of the two groups showed that 17 out of the 29 sows (58.6%) expressed "post-partum" heats one to three days after farrowing. These heats lasted from one to three and a half days and none of the sows conceived when bred. "True" heats were expressed by 22 of the 29 sows (75.9%) eight to 16 days after farrowing. The duration of these heats was from two to six days, and 92.5% of the 197 recovered ova were fertilized. Four sows had exhibited no "true" heat when slaughtered on day-21 and three sows none by day-31. The data suggests that neither suckling nor the expression of "post-partum" heat had any over-all effect on the number of corpora lutea produced from the "true" heat. However, three non-suckling sows which failed to show a "post-partum" heat tended to have cystic ovaries with few or no corpora lutea.

A PREGNANCY TEST FOR MARES USING THE MALE TOAD (BUFO). R. O. Berry and J. F. Spalding, *Agricultural and Mechanical College of Texas.*

Tests for pregnancy were made on 35 mares from 45 to 105 days after breeding by injecting 3 cc. of blood serum into the lymph spaces of the male *Bufo woodhousi* and *Bufo valliceps*. Twenty-four positive and 11 negative tests were obtained. All of the positive tests were correct. Three of the negative later proved to be false. The error was probably due to a depleted condition of the toads. The test is based upon the principal that the male toad will emit sperm only when in amplexus with a female or when stimulated with injections of the gonadotropic hormone. In positive tests sperm are produced within 4 hours after injection of the serum. An individual toad can be used repeatedly by allowing about 10 days between each test. If kept under favorable laboratory conditions the toads can be used the year round. We feel that the test is

superior to former biological test for pregnancy because of (1) natural abundant supply of toads, (2) the hardiness of these animals, (3) the short interval of time necessary for obtaining results and (4) the simplicity of the test. Toads have also been used in human pregnancy tests with excellent results.

THE EFFECT OF TESTOSTERONE PROPIONATE ON RATE OF GAIN, FEED EFFICIENCY, AND CARCASS QUALITY OF BEEF HEIFERS AND STEERS. Martin J. Burris, Ralph Bogart, A. W. Oliver, and Andrea Overman Mackey, *Oregon State College.*

This report includes the second year of a study designed to determine the importance of male hormones in the physiology of growth differences found between heifers, steers and bulls. Six steers and six heifers were injected weekly with 1 mg. per kg. of body weight of testosterone in the form of aqueous suspension of micropellets (Oreton-F, Schering). A control group of six steers and six heifers sired by the same bulls as those receiving testosterone was used. The test period was from 500 to 800 pounds. Gain and feed records were kept during this period and at 800 pounds all animals were slaughtered and carcass data and determinations of meat quality were made. Testosterone injection increased the rate of gain of heifer calves 0.5 pounds per day and of steer calves about 0.1 pounds per day. Testosterone treated heifers required 120 pounds less TDN than did non-treated heifers while treated steers required about 30 pounds less TDN per hundred pound gain in body weight. Both heifers and steers treated with testosterone showed certain secondary masculine sex characteristics. Control calves had a slightly greater dressing percent than testosterone treated calves and the percent of rear quarter was 0.8 percent greater for the control calves. There was very little difference in palatibility or cooking quality between meat from control and testosterone-treated animals. Shearing tests indicated that roasts from control steers were more tender than those from control heifers and testosterone steers and heifers.

PUBERTY AND OTHER REPRODUCTIVE PHENOMENA IN GILTS AS AFFECTED BY PLANE OF NUTRITION. R. E. Christian and J. C. Nofziger, *The State College of Washington.*

A total of 91 gilts, 41 high plane (HP) which were self-fed and 50 low plane (LP) which were fed approximately 70 percent of full feed, were checked daily, beginning at 120 days of age, with vasectomized boars to determine age at puberty and length of subsequent estrual cycles. These gilts were from the fourth generation of pigs raised on their respective planes of nutrition. At 150 pounds, both planes were put on a breeding ration until bred, then returned to their respective planes. The average age at puberty for HP gilts was 170.2 days, for LP gilts, 166.8 days ($P>.05$). The HP gilts averaged 178.0 pounds, and the LP gilts 128.0 pounds at puberty ($P<.01$). During the breeding season (December 1 to December 31) 40 gilts, 20 from each plane, were bred to produce the next generation; the 51 remaining were bred and slaughtered the day following the cessation of heat, to supply ovulation and fertilization data. Ovulation rate for HP gilts was 15.1 as compared with 13.4 for LP gilts ($P<.05$). The fertilization rate for HP gilts was 83.2 percent, for LP 85.5 percent ($P>.05$). HP gilts farrowed an average of 4.7 live pigs per litter and LP gilts farrowed an average of 7.4 live pigs per litter ($P<.01$). Prenatal death rate was estimated as 62.9 percent for HP gilts and 35.3 percent for LP gilts.

EFFECTS OF FLUORINE ON SKELETAL METABOLISM AND BONE GROWTH IN PIGS AS SHOWN WITH RADIOCALCIUM. C. L. Comar, W. J. Visek, W. E. Lotz, and John E. Rust, *University of Tennessee-Atomic Energy Commission Agricultural Research Program.*

The interrelated effects of dietary fluorine and feed intake on bone growth, body growth, Ca^{45} behavior, bone pathology and feed utilization are demonstrated in pigs. The animals were placed on the assigned ration for 30 days, injected with radiocalcium, kept on the assigned ration for 45 days more, and then sacrificed. Bone growth was measured directly from autoradiographs in mm. of length increase in the distal end of the femur during the 45 days. Other measurements and handling followed recommended practice. On *ad libitum* feeding, a fluorine level of 200 p.p.m. showed no effects, but 1,000 p.p.m. reduced the bone growth from 10 to 5, reduced the weight gain from 1.9 to 0.4 lbs. per day, increased the feed requirement from 4.7 to 6.5 lbs. of feed per lb. of gain, and reduced the feed requirement from 40 to 22 lbs. of feed per unit of skeletal growth. When feed intakes were equalized to that of the high fluorine lots the values for the basal ration, 200 p.p.m. fluorine and 1,000 p.p.m. fluorine were respectively: bone growth—7.9, 6.5 and 5.3; lbs. of feed per lb. of gain—7.5, 8.7 and 9.4; lbs. of feed per unit of skeletal growth—17, 21 and 25. Autoradiographic, x-ray and histologic observations of the bones showed two fluorine effects: (1) a dysfunction in the proliferating zone of the epiphysis, related to the reduction of bone growth, and (2) a dysfunction in the primary and secondary spongiosa, apparently related to an increased rate of bone resorption in these areas.

THERMAL HYPERPNEA AND THE ACID-BASE BALANCE IN DAIRY CATTLE. Homer E. Dale and Samuel Brody, *University of Missouri.*

Dairy cattle exposed to environmental temperatures rising from 80° to 105° F. develop a 40% reduction in the CO_2-combining capacity of the blood plasma. This decrease could be due either to an excessive blowing off of CO_2 consequent to a thermal hyperpnea (respiration rate up to 150 at 105° F.) or to an excessive production of ketone bodies and other metabolic acids as a result of the progressive reduction in the feed intake. To clarify this problem, eleven cows were subjected to temperatures of 65° to 105° F. at controlled humidity and wind velocities. The following blood analyses were made: pH, ketone bodies, CO_2-combining capacity, and acid-base ratio. To differentiate the effects of starvation from thermal stress, four cows were fasted for 120 hours at thermoneutrality. In the fasting animals the concentration of ketone bodies in the blood plasma increased up to twelve-fold normal by the fifth day of the fast and this was not accompanied by a change in the CO_2-combining capacity or pH of the blood. The animals subjected to rising temperatures did not show an increase in the concentration of ketone bodies but the CO_2-combining capacity of the plasma declined and the pH of the blood increased. The tentative conclusion is that the observed decrease in the CO_2-combining capacity is due to a respiratory alkalosis (blowing off CO_2) and is not due to metabolic acidosis (production of ketone bodies and other metabolic acids as a result of heat stress).

EFFECT OF HIGH DIETARY POTASSIUM ON SHEEP. Odell Daniel, E. E. Hatfield, W. C. Shrewsberry, M. E. Gibson, and Robert MacVicar, *Panhandle A. and M. College and Oklahoma Agricultural Experiment Station.*

In a study of the etiology of wheat pasture poisoning, investigations were made of the effect of high dietary potassium intake on sheep. During the first

year, 40 purebred Hampshire and 40 western ewes were divided into four lots and treated as follows: Lot 1, fed in dry lot a ration composed of ground sorghum fodder, ground milo and molasses; Lot 2, same as Lot 1 plus 4.2 percent KCl; Lot 3, grazed wheat pasture from October to May; Lot 4, same as Lot 3 plus 4.6 gm. of $CaCl_2$ per head per day in drinking water. No significant effect of supplementation with KCl or $CaCl_2$ was noted on: weight of ewes, weight of lamb at birth or at 60 days; number of lambs dropped or raised; or physiological state as indicated by blood plasma levels of potassium, sodium, calcium, magnesium and phosphorus. Blood plasma magnesium tended to decrease in animals of Lots 3 and 4 during periods of lush growth of wheat. Blood inorganic phosphorus declined during late gestation and remained depressed during heavy lactation. No symptoms indicative of wheat pasture poisoning were observed. In the succeeding year the experiment was repeated with 40 ewes as follows: Lot 1, fed in dry lot a pelleted mixture of ground sorghum fodder and milo; Lot 2, same as Lot 1 plus 7.7 percent KCl; Lot 3, grazed wheat pasture (only during April–May because of unfavorable growing season); Lot 4, as Lot 3+116 gm. KCl per head per day in drinking water while on pasture. As in previous year, no adverse effects of KCl administration were noted. Blood plasma composition was unaffected by treatment. A decline in plasma inorganic phosphorus during late gestation and following parturition was again observed.

PLACENTAL TRANSFER OF ZINC. George K. Davis, John P. Feaster, and Sam L. Hansard, *Florida Agricultural Experiment Station.*

In studies with rats and cattle, using radiozinc, it was found that individuals vary widely in their ability to absorb zinc from the intestinal tract and in pregnant females there appeared to be a relationship to the stage of pregnancy. Increased zinc was absorbed by the females in the last third of gestation. In rats the results indicate that most if not all of the zinc which crosses the placenta to the fetus is first deposited in the maternal tissues. The data indicate that increased fetal size affects zinc laydown more than age. Concentration of zinc in the body undergoes "dilution" with age ranging from 12–15 parts per million, dry matter basis, in the fetal animal to 4–7 parts per million, at maturity. Zinc is readily transferred to milk with 28% of the absorbed dose found in the milk within 96 hours.

THE RELATIONSHIP OF MILK LETDOWN FACTORS TO MILK PRODUCTION. J. D. Donker, W. E. Petersen, M. C. Hervey and James Koshi, *University of Minnesota.*

Data from one set of monozygotic twins is presented. Twins T-63 and T-64 in their first lactations produced 183.3 pounds milk containing 4.68 lbs. fat (test 2.55) in 58 days and 316.5 lbs. milk containing 9.35 lbs. fat (test 2.95) in 53 days respectively. Twin T-63 in her second lactation produced 1,071.0 lbs. milk containing 38.61 lbs. fat (test 3.60) in 85 days. Twin T-64, commencing after the first week, received an intravenous injection of oxytocin following each regular milking and was then again milked to obtain the residual milk. In 105 days of a lactation still in progress her total production has been 3,199.2 lbs. of milk containing 101.66 pounds fat (test 3.18). The regular milkings contributed 2,066.8 lbs. of milk while an additional 1,132.4 lbs. were recorded as residual milk. The averages of 12 weekly fat tests were 1.23 and 6.56% for the regular and residual milks respectively. Two day composites of the regular and residual milks showed only a difference in fat content when the other major constituents were corrected, to a fat free basis in the plasma. The constituents

tested were fat, solids not fat, total protein, casein, serum protein, globulin, non-protein nitrogen, lactose, minerals, calcium, phosphorous, chloride, pH, titratable acidity and specific gravity.

INDUCTION OF ESTRUS AND OVULATION IN ANESTRUAL EWES BY USE OF PROGESTERONE AND PREGNANT MARE SERUM. R. H. Dutt, *University of Kentucky.*

Preliminary work has shown that both estrus and ovulation can be induced in anestrual ewes by injecting progesterone prior to pregnant mare serum (PMS). This experiment is a further study of the action of progesterone in this respect. Seventy-two Hampshire-cross western ewes were randomly allotted into 8 groups of 9 ewes each. Each group received one of the following treatments: (1) control; (2) one injection of 500 IU of PMS; (3) five injections of 30 mg. of progesterone at 3 day intervals; and, (4) 5 groups (4 through 8) received respectively—1, 2, 3, 4, and 5 injections of 30 mg. of progesterone at 3 day intervals followed by an injection of 500 IU of PMS. The ewes were checked for estrus during treatment and for 10 days after end of treatment. Ewes showing estrus were bred and slaughtered 3 days later. Ewes which did not come into estrus within 10 days after end of treatment were slaughtered. None of the control ewes came into estrus during the experimental period and none had ovulated. None of the ewes receiving PMS alone came into estrus but all had ovulated. Four of the 9 ewes receiving only progesterone came into estrus and ovulated. All ewes in the group receiving 5 injections of progesterone and then PMS came into estrus and had ovulated. Ewes receiving from 1 to 4 injections of progesterone prior to PMS had ovulated, but not all of the ewes came into estrus in any of these groups. The highest percentage of ewes came into estrus in the groups which had received progesterone for the longest period of time. Forty-nine percent of the ova recovered from all groups were fertilized.

EFFECTS OF STILBESTROL-PROGESTERONE IMPLANTS ON GROWTH AND CARCASS QUALITY OF LAMBS. J. H. Galloway, L. J. Bratzler, L. H. Blakeslee, and J. Meites, *Michigan State College.*

Two lots of ten feeder lambs each were put in dry lots and divided equally by weight, sex, breed and type. Group 1 was the control lot and Group 2 received 25 mg. of diethyl-stilbestrol and 250 mg. of progesterone per lamb, implanted subcutaneously in the neck. Both lots were fed cracked corn and hay for ninety days. During the 90-day experimental period, two lambs were removed from each lot due to death or unthriftiness. At the end of the feeding period, the lambs were slaughtered, hot and cold dressing percents computed, and carcasses graded by U.S.D.A. standards. From each carcass a nine-rib rack was removed and physically separated into fat, lean, bone and ligament. A sample of fat from each carcass was analyzed for water content. The results showed that the treated lambs required less feed per pound of gain, had more rapid gain, more finish, higher dressing percentages, and higher carcass grades than the controls. There was no difference in the water content of the fat between the treated and control lambs. The treated lambs gained 0.42 lbs. per day compared to 0.31 lbs. per day for the controls, averaged 10 pounds heavier per lamb at the end of the experiment, and consumed 20% less feed than the controls.

THE ISOLATION OF TWO OR MORE METABOLITES FROM THE URINE OF THE PREGNANT SOW AND THEIR RELATION TO FACTORS INFLUENCING LITTER SIZE IN SWINE. Betty Ruth Glasgow and Dennis T. Mayer, *Missouri Agricultural Experiment Station.*

Analyses were made for metabolic products of progesterone in the urine of the sow throughout the gestation period. A method for the colorimetric determination of the excretion products of progesterone in the urine of the pregnant sow was previously developed. During the investigation of the hydrolysis of the conjugated metabolites, we observed an unconjugated form present prior to hydrolysis. Our results suggest at least two pregnane derivatives: one in the free form and extractable with toluene without previous hydrolysis and a second in the conjugated form which requires acid hydrolysis prior to extraction. An investigation was made to determine whether these two products consisted of ketonic, non-ketonic, or both types of steroids. The free steroids, obtained by the usual methods of separation, were chromatographed on a silicate-Celite column. Chromatography of the extract of unhydrolyzed urine yielded both ketonic and non-ketonic steroids. The extracts from the hydrolyzed urine contained only a non-ketonic steroid, which is present in the conjugated form in sow's urine. There is a close relationship between amounts of these two products present during the entire gestation period. Both metabolites are present in a lower concentration during early gestation and after the sixth week there is a two or three fold increase in concentration.

THE EFFECTS OF AGE UPON CALCIUM METABOLISM IN CATTLE. Sam L. Hansard, C. L. Comar, M. P. Plumlee, and Geo. K. Davis, *University of Tennessee and University of Florida.*

Results from tissue distribution and 7-day balance studies following oral and intravenous administration of radiocalcium to 28 selected Hereford cattle 10-days to 12-years of age indicated that: (1) 10 day old animals absorbed 4 times as much ingested Ca^{45} as did yearlings and 5 times as much as 12 year old cattle. (2) Oral and i.v. administration gave the same results in calves under 60 days of age due to high absorption of ingested calcium. (3) Rate of fecal excretion after ingestion was faster in the older animals. (4) After i.v. administration younger animals excreted less total calcium but at a higher rate. This was reflected in the slower removal of injected Ca^{45} from blood of older animals. (5) Values for total calcium, ash and phosphorus in soft tissues were the same for animals of all ages, but the older animals showed higher values in bones such as mandible, vertebra, metatarsus and rib epiphysis. (6) The pattern of Ca^{45} distribution as shown by radioassay was the same in the soft tissues for animals of all ages, but in the skeletal tissues mentioned above there was a decreased laydown in the older animals which paralleled the decreased metabolic activity. (7) Autoradiographs of the metatarsal bones from animals of all age groups confirmed the above conclusions in regard to the correlation of laydown and metabolic activity. The heaviest laydown was below the epiphysis, with spotty distribution in the trabecular bone, and a sharp line of laydown beneath the periosteum. In old animals, with fused epiphyses, there was no localized epiphyseal laydown.

THE EFFECT OF ESTRADIOL ON OVULATION TIME IN DAIRY HEIFERS. W. Hansel, G. W. Trimberger, and H. J. Bearden, *Cornell University.*

In a recent experiment it was found that progesterone administered to dairy heifers at the beginning of estrus hastened ovulation. An identical experiment

in which estradiol was substituted for progesterone has been carried out. The length of estrus and the time of ovulation were determined for 14 heifers in a control estrous period and in an estrous period in which estradiol (1,000–3,000 I.U.) was injected subcutaneously at the beginning of heat. The length of estrus in the control periods averaged 19.2 hours and the time of ovulation averaged 10.6 hours after the end of estrus. During the periods of estradiol treatment the length of estrus averaged 21.0 hours and ovulation occurred 11.7 hours after the end of estrus. The total time from the beginning of estrus to ovulation was 29.8 hours in the control periods and 32.4 hours in the treatment periods. The failure of estradiol to hasten ovulation and the ability of progesterone to do so when administered at the beginning of estrus indicate that the currently accepted concept that the rising level of blood estrogen at the time of estrus causes the inhibition of F.S.H. output and the release of L.H. by the anterior pituitary may need revision.

A DETERMINATION OF THYROID SECRETION RATE IN INTACT INDIVIDUAL SHEEP. H. A. Henneman, S. A. Griffin, and E. P. Reineke, *Michigan State College.*

A method has been devised to determine the daily thyroid secretion rate in intact individual sheep. One microcurie of I^{131} per pound of body weight is injected subcutaneously. At seven and ten days post injection, base counts are taken over the thyroid gland with the Geiger counter. A background count is taken on the outside of the foreleg. Four additional counts are taken at three-day intervals. For the first three-day period following the determination of the base counts the sheep are handled the same as during the base period; for the second three-day period a small quantity of 1-thyroxin is injected daily; during each successive three-day period the 1-thyroxin is increased progressively. It is important that the maximum amount of 1-thyroxin injected daily remain below the actual secretion of the sheep. The counts are then corrected for background and decay and the percentage of the previous corrected count is computed. As the quantity of 1-thyroxin injected daily is increased the percentage of the previous count increases, indicating that the thyroid itself is secreting less thyroxin. Correlation coefficients, significant at the one percent level, have been obtained between the 1-thyroxin injections and the percentages of previous counts. By use of the prediction equation, values for daily thyroid secretion have been estimated. These values have ranged from .05 mg. to .5 mg. of 1-thyroxin equivalent for different groups of sheep under varying environmental conditions.

EFFECTS OF CAROTENE ADMINISTERED ORALLY, INTRAMUSCULARLY AND INTRAVENOUSLY ON AVITAMINOSIS A IN PIGS. J. F. Hentges, Jr., R. H. Grummer, and D. K. Sorensen, *University of Wisconsin.*

Studies were conducted to compare the effects of orally, intramuscularly, and intravenously administered carotene on the blood plasma vitamin A levels of vitamin A deficient pigs. Carotene in cottonseed oil administered intramuscularly remained at the site of injection and was not effective in relieving avitaminosis A. Water-miscible preparations of carotene in Tween 80, administered either intramuscularly or intravenously, resulted in increased blood plasma vitamin A levels within four hours and complete recovery from the symptoms of avitaminosis A. Orally administered carotene was converted to plasma vitamin A most rapidly while intravenous injections were utilized before intramuscular injections; however, all three methods ultimately afforded complete recovery

and normal plasma vitamin A values. Since carotene is not a normal constituent of swine blood and the intestinal wall is thought to be the site of conversion of carotene to vitamin A in swine, studies were conducted to determine the site of conversion of carotene administered intramuscularly and intravenously. Analyses on samples of bile collected hourly after parenteral administration of carotene did not reveal measurable amounts of carotene in the bile. Ligation of the anterior mesenteric, posterior mesenteric and coeliac arteries in addition to cannulation of the common bile duct did not prevent intramuscularly administered carotene from being converted to plasma vitamin A.

SOME EFFECTS OF FEEDING TRACE MINERALS AND OTHER DIETARY CONSTITUENTS ON THE HEMATOLOGY OF THE DAIRY CALF. W. G. Jones, E. E. Bartley, M. J. Swenson, and G. K. L. Underbjerg, *Kansas State College.*

Numerous hematological variations have been reported in the bovine that have been attributed to dietary differences. These variations have been shown to have a pronounced effect upon the metabolic activity of the animal. A pilot experiment was conducted in which certain hematological values for 30 dairy heifers of 4 breeds, ranging in age from 3 to 10 months, were fed 3 different rations. The starter and skimmilk systems of feeding were used. The ration groups were: I. starter system with aureomycin; II. skimmilk system with aureomycin; III. skimmilk system without aureomycin. For each group the av. grams percent hemoglobin, erythrocyte count, packed cell volume (mm^3), mean corpuscular vol. ($c.\mu$), mean corpuscular hemoglobin ($\gamma\gamma$) and the mean corpuscular hemoglobin concentration (%) respectively were: Group I, 13.59, 10.60×10^6, 38.5, 36.71, 12.75, 35.36; Group II, 11.75, 8.23×10^6, 32.0, 36.30, 14.48, 36.92; and Group III, 12.33, 7.52×10^6, 35.3, 47.92, 16.63, 34.82.

EFFECT OF STILBESTROL ON CARCASS QUALITY AND SHRINKAGE AND NITROGEN RETENTION BY LAMBS. R. M. Jordan and T. Donald Bell, *South Dakota State College and Kansas State College.*

Carcass data gathered on lambs treated with 12 mg. of stilbestrol as compared to untreated lambs revealed that: (1) Of the untreated lambs, 15 graded prime and 3 choice, of the treated lambs, 8 graded prime and 11 choice. (2) Carcass yield, untreated lambs, 48.8%, treated lambs 47.6%. The treated lambs were more mature appearing, and the pelts were more difficult to remove. When fed a sufficient period of time (90–100 days) the treated lambs finished out with satisfactory covering from packers standpoint and weighed about 8 pounds more than the controls fed the same length of time. (3) Data from three additional lambs from each group fed for 80 days showed that the untreated lambs yield 3.5% more than the treated lambs. Carcass of treated lambs shrank 2.98% during the first 72 hours after slaughter as compared to 2.11% for the untreated lambs. Cooking tests showed little difference in loss of water vapor between the treated and untreated lambs. However, the meat drippings from the untreated lambs contained 50.40% fat and 49.60% meat juice as compared to 39.25% fat and 60.75% meat juice from the treated lambs. The total loss from meat drippings was about the same in both groups. Amount of moisture, fat, and nitrogen in meat was about the same in both groups of lambs that were equal in carcass grade. Metabolism trial showed no difference in digestion ability of treated or untreated lamb. Neither was there a significant difference in the amount of nitrogen retained between the lambs of the two groups.

COMPARATIVE FERTILIZATION RATES OF BULLS WITH HIGH AND LOW NON-RETURN RATES. H. E. Kidder, W. G. Black, L. C. Ulberg, and L. E. Casida, *University of Wisconsin and U. S. Department of Agriculture.*

A comparison is being made of the fertilization rates of bulls of high and low non-return rates. One heifer has been inseminated with semen of each of these bulls and slaughtered on the third day to determine the normality of the heifer and the presence of a fertilized egg. Altogether 50 heifers have been examined and conditions probably preventing fertilization have been found in 16% of them. Semen from 22 high fertility bulls (average non-return rate 71.4%) and 20 low fertility bulls (average non-return rate 55%) has been tested. Ova recovered from 21 out of 22 of the heifers inseminated to high-fertility bulls have been fertilized (95.5%); this is in contrast to 15 fertilized ova out of 20 (75%) from heifers inseminated to low fertility bulls. The greatest difference between bulls of high and low non-return rate would appear to be in their fertilization rates, 20.5% in favor of the high bulls. Differences in embryonic death would appear to contribute very little, the present estimates being 28% and 33.9% (difference 5.9%) for the high and low bulls respectively. The results suggest that further improvement in breeding efficiency within the present limits of age-of-semen-used must come from the culling of low fertility bulls and from the prevention of embryonic death.

PLASMA PBI CHANGES IN NEW-BORN CALVES. R. C. Lewis and N. P. Ralston, *Michigan State College.*

The plasma protein-bound iodine concentrations of cows immediately after calving averaged 2.5γ percent while the corresponding levels of a week before and three days after calving were 4.5 and 4.6γ percent respectively. This difference was statistically highly significant. New-born calves averaged 8.9γ percent but the level rose to 15.0γ percent within twelve hours and then fell to the initial level within three days. The PBI concentration of the first colostrum averaged more than 25.0γ percent but rapidly decreased to the level of milk which was about 6.0γ percent. These data indicate that relatively large amounts of protein-bound iodine are concentrated in colostrum along with the globulin and albumin fractions. Histological sections of the thyroids of calves thyroidectomized at intervals up to six days after birth showed marked increases in colloid accumulation and tissue differentiation. The significance of these early changes is not known but it is suggested that they are related to the physiological adjustment of the calf to its new environment.

COMPARATIVE HEAT TOLERANCE OF JERSEYS AND SINDHI-JERSEY CROSSES. R. E. McDowell, D. H. K. Lee, and M. Schein, *U. S. Department of Agriculture, Johns Hopkins University, and Louisiana State University.*

Five hundred and fifty-seven studies have been made at Beltsville, Md. on the effect of 6 hours exposure of dairy cattle to a standard hot atmosphere (105° F., 34 mm^{Hg} vapor pressure, 60% rel. humidity). Three hundred and forty-seven of the tests were on Jerseys, 210 on Sindhi-Jersey (F_1) crosses. The mean body temperature of the crosses during exposure was lower than that of the Jerseys at all ages, stages of lactation, and levels of production. There was some overlap, however, in the range of variation, so that some Jerseys were as low or lower than some crosses. The mean body temperature during exposure of both Jerseys and crosses fell with age in heifers, rose markedly with the

onset of lactation, but tended to fall as lactation continued. It was markedly higher with the higher levels of lactation. Respiratory volume and respiratory rate studies on 16 animals showed no important differences between the Jerseys and the crosses. In both groups a marked rise of both rate and volume occurred with exposure to heat, the rise of volume being positively correlated with rise of body temperature.

VARIATION IN THE PERCENT RED CELL VOLUME OF THE BLOOD OF SHEEP. G. B. McLeroy, E. T. Brown, and W. A. Smith, *Arizona State College at Tempe.*

In an endeavor to ascertain some of the physiological processes involved in the greater heat tolerance of Rambouillet sheep as contrasted to that of the Suffolk under the extreme heat of central Arizona, the percent red cell volume (Hematocrit-Wintrobe) of the blood of such animals was investigated. Thirty-two pure-bred animals from the college flock were involved, consisting of eight ewes and their lambs from each of the two breeds. Blood samples were taken in April, representing cool weather and again in late June, representing the hot summer season. The average hematocrit values obtained were as follows: Rambouillet 46, Suffolk 44; April 49, June 40; Lambs 47, Ewes 42. The overall average was 44.7 ± 6.5. These data suggest that differences in percent red cell volume probably have no profound relationship to heat tolerance since breed differences were not significant. Further, the lambs had significantly higher hematocrit values than their dams yet it has been observed that the incidence of heat exhaustion is much higher in the case of lambs. Lastly, there was a real and pronounced decrease in percent red cell volume with the advent of high summer temperatures.

EFFECTS OF VACUUM LEVEL AND MILKING DURATION ON UDDER HEALTH IN MASTITIS-FREE FIRST CALF HEIFERS. R. D. Mochrie, H. H. Hale, H. D. Eaton, F. I. Elliott, and W. N. Plastridge, *University of Connecticut.*

Three Jersey and 9 Holstein heifers mastitis-free for the first 4 weeks of lactation were randomly assigned with restriction as to breed to vacuum levels of 10, 13, or 17 in. of mercury and each half of each udder to a milking duration of "normal" or "twice normal." "Normal" milking duration was defined as the length of time from the attachment of the milker until the rate of flow for that half fell to ≤ 0.1 lb./15 sec. interval. The "twice-normal" half had the machine left on for a total of twice its own normal milking duration. Milking was done by 2 operators using 2 goat-claw, bucket-type milkers on each cow. Milking durations were adjusted weekly for each half. Cows were milked in this manner from the 5th through the 44th week of lactation. Chloride, leucocyte count, pH, and presence of mastitis organisms were determined on quarter samples taken twice-weekly during the course of the experiment and showed no significant differences for vacuum levels. Av. Cl^- content and av. log of the leucocyte count adjusted for the values obtained during the third and fourth week postpartum were found to be greater for those halves milked for the normal duration than for the twice normal ($P<0.01$, $P<0.05$). A trend analysis indicated that pH as well as Cl^- and log of the leucocyte count of the normal halves increased at a greater linear rate than the twice normal halves ($P<0.05$, $P<0.01$, $P<0.05$). Six quarters which became clinically affected with mastitis during the comparison period did not appear to be related to treatment.

SEASONAL VARIATIONS IN HEAT PRODUCTION OF CATTLE AND BUFFALOES. D. N. Mullick and N. D. Kehar, *Indian Veterinary Research Institute.*

Recent observations made in these laboratories showed that Indian cattle require 25% less protein and about 20% less calories for maintenance than the standards advocated by Morrison. These studies have been further extended to determine the effect of different mean temperature (50° to 100° F.) on heat production in buffalo and different breeds of cattle. This range of temperature was selected, because it simulates the natural outdoor conditions from December to June. The experimental observations were made on twelve Hariana cows, three foreign cross and three Murrah buffaloes. Standard technique in the collection and analysis of the expired gas was followed. The collections were made in the morning after 16–18 hours of feeding, the gas was analyzed for CO_2, O_2 and CH_4 and the calories per hour were calculated from the chemical analysis of gases and respiratory quotient. The resting metabolism per unit surface area was also calculated. The heat production per hour of Hariana and Cross cows and buffaloes decreased with the increase in air temperature. The mean values with their standard deviations are 386 ± 37, 394 ± 37 and 485 ± 31 respectively and the mean differences are significant. The total number of calories per hour per square meter of body surface showed a negative correlation with air temperature and the values were highly significant. The mean values with standard deviations are 99.0 ± 8.8, 107.0 ± 8.7 and 107.0 ± 5.1 for Hariana, foreign cross cows and buffaloes.

THE DISTRIBUTION IN THE YOUNG DAIRY CALF OF ORALLY ADMINISTERED P^{32}. R. H. Olson, R. S. Allen, and N. L. Jacobson, *Iowa State College.*

Two young male Jersey calves were fed 2 and 5 millicuries, respectively, of radioactive phosphorus ($H_3P^{32}O_4$) in milk. Several samples of blood were drawn during the subsequent 24-hour period and at less frequent intervals thereafter. The calves were sacrificed after 3 and 6 days, respectively, and samples of various tissues were collected. The blood and tissues were analyzed for phosphorus and for P^{32} activity by conventional methods. The radioactivity was first observed in the plasma portion of the blood as inorganic phosphorus and maximal levels were found at approximately 4 hours. Subsequently the radioactivity in the plasma decreased rather abruptly while that in the blood cells increased and then tended to decline slowly with time. The P^{32} activity in the plasma inorganic phosphorus decreased markedly during the 4- to 24-hour period and subsequently declined at a slower rate. The plasma lipid and organic ester phosphorus fractions reached maxima between 8 and 16 hours and subsequently decreased gradually. There was considerable variation among the various tissues with respect to P^{32} uptake. Those which contained considerable radioactivity included the bone epiphysis, bone diaphysis, testes, spleen, liver, kidney and lymph nodes. Significant amounts also were found in the tissues of the intestinal tract, particularly as lipid phosphorus, and in the gastrocnemius muscle. Radioautographs of cross sections of the tibias indicated a high concentration of P^{32} in the bone epiphysis.

THE RATE OF ABSORPTION OF FATTY ACIDS FROM THE RUMEN OF SHEEP. W. H. Pfander and A. T. Phillipson, *Rowett Research Institute.*

In a series of acute experiments the absorption of fatty acids from the rumen of sheep was measured when the concentration of fatty acids, inorganic salts, CO_2 tension, and pH were maintained at levels similar to those found in the rumen of feeding sheep. Continuous measurements of fatty acid absorption

from the rumen of sheep feeding or fasting were made. The absolute rates of absorption were found to be similar to those in the acute preparations, and were in the order acetic>butyric>propionic. It has been calculated that the fatty acids absorbed could provide 50% of the energy requirement for maintenance of these sheep.

TOXIC EFFECTS ON CATTLE OF TRICHLOROETHYLENE-EXTRACTED SOYBEAN OIL MEALS. J. C. Picken, Jr., N. L. Jacobson, R. S. Allen, P. C. Bennett, and H. E. Biester, *Iowa State College.*

A fatal hemorrhagic disease (of cattle) associated with the ingestion of commercially prepared trichloroethylene-extracted soybean oil meal has been observed recently in numerous areas of the United States and in Hawaii and Japan. A review of these cases and earlier outbreaks in Scotland and Europe has been presented by Prichard *et al.* (J.A.V.M.A., 121:1, 1952). In the present investigation 41 animals, ranging in initial age from 10 days to 15 months, were employed to ascertain the toxicity of several commercially produced trichloroethylene-extracted soybean oil meals. Hexane-extracted soybean oil meal was fed in the control diet to 10 animals with a similar age range. The soybean oil meals were added to rations considered nutritionally adequate. All trichloroethylene meals were toxic, although differences in degree of toxicity were observed. Thirty-two of the 41 animals have died and the remainder present the typical clinical manifestations. In some instances deaths occurred in 4 weeks with meal consumptions as low as 12 to 15 pounds. Hematological studies revealed leucopenia and agranulocytoses. Characteristic terminal symptoms also included morbidity, anorexia, elevated body temperatures (106°–108° F.) and bloody discharges from the nostrils and in the feces. Postmortem examination revealed extensive hemorrhaging throughout the body. Antibiotics and sulfonamides administered therapeutically did not change appreciably the course of the disease. Moreover, oral administration of menadione, rutin, thiamine, riboflavin, niacin, folic acid and pyridoxine were effective neither prophylactically nor therapeutically. No abnormalities were apparent among any of the animals fed hexane-extracted meal.

VARIABLES RELATED TO HYDROLYSIS AND EXTRACTION OF BOVINE URINARY CORTICOIDS AS MEASURED BY THE PHOSPHOMOLYBDIC ACID REDUCTION METHOD. William G. Robertson and John P. Mixner, *New Jersey Experiment Station.*

The bovine urinary corticoids are present in the conjugated form and hydrolysis is necessary prior to extraction with fat solvents. Several factors related to hydrolysis and extraction were studied. In all instances 12M H_2SO_4 was used as the hydrolyzing agent; hydrolysis was carried out at room temperature; chloroform was used as the extracting agent utilizing separatory funnels and hand shaking. (1) For hydrolysis, the acid was varied from none up to equal parts of acid and urine. Optimal level of acid was found to be 10 ml./100 ml. urine. (2) In the extraction studies several chloroform to urine ratios including serial extractions were used. A single 2:1 chloroform to urine extraction was found to be satisfactory. (3) In the washing and purification of the chloroform extract NaOH is necessary to remove estrogens, phenolic compounds, etc. A comparison was made between a conventional 0.1 N NaOH wash and a mechanical skaking of the extract with solid NaOH pellets at the rate of 20 gms. pellets/100 mls. extract. The latter procedure has several advantages and was adopted. (4) The effect of the length of the hydrolysis period on steroid recovery was studied. Assay results showed an initial rise from 0–2 hours, a plateau from 2–4 hours,

a second rise from 4–8 hours and a second plateau from 8–12 hours. For uniformity of results a 3 hour hydrolysis period was felt to be optimum.

SOME EFFECTS OF THE MALE HORMONES ON THE BOVINE AS DETERMINED BY BODY MEASUREMENTS. C. F. Rothe, N. S. Fechheimer, C. S. Baldwin, and L. O. Gilmore, *Ohio State University.*

Seventeen measurements were made weekly to investigate the nature and extent of secondary sex characteristics in cattle caused by the male sex hormones. The measurements were general growth as indicated by body weight, distance from shoulder point to shoulder point, skeletal growth as indicated by height at withers, circumference of chest, length from poll to muzzle, length from the angle of the mandible to end of mandible, circumference of metacarpus and metatarsus, width of hooks, thurls and pins and length from hooks to pins. Muscular development was indicated by the contour distance from stifle to stifle and circumference of neck. The experimental subjects were a pair of identical twin freemartins with palpable, morphologically normal testes present at birth and their male triplet. A larger body of data from more than 50 genetic males furnished a background for the study. The data presented here came from genetic females. After uniformity studies one freemartin was gonadectomized and the effect on the above measurements noted. Subsequently, testosterone propionate ranging in amount from 12.5 to 100 mg. per day was injected at intervals varying from 2 to 5 weeks. When the data were analyzed by use of the "t" test with paired comparisons, significant differences were found for body weight, width of shoulders, heart girth, depth of chest and circumference of neck. No significant differences were found for length of head, width of head, length of mandible, pelvic measurements, circumference of metacarpus and metatarsus or stifle to stifle.

CHARACTERISTICS OF SEMEN PRODUCTION BY YEARLING RAMBOUILLET RAMS FROM JANUARY TO JULY. Mario Schwarz, N. B. McCleery, Ralph M. Durham, and P. E. Neale, *New Mexico College of A. & M. A.*

Two collections by artificial vagina were attempted from each of two yearling Rambouillet rams twice weekly and from a third ram once monthly from January 1 to June 1. Daily collections were attempted from three rams and weekly collections from one ram during the period from June 1 to July 3. The vagina temperature was maintained from 120° to 130° F. depending on the ram. There were marked differences in libido and sperm production among the rams which were half sibs. When exhibiting poor libido they could generally be induced to serve the vagina by lifting them on a dummy, although they did not always ejaculate. Semen volume varied from a drop to more than 1 cc. per ejaculate. Sperm counts varied from as low as 50 million per cc. to nearly 5 billion per cc. Motility was graded visually as to the intensity of sperm mass movement. Correlations within rams and months between semen volume and sperm concentration were positive during the January through May period. A significant positive correlation was found within rams and months between volume and concentration, for the second ejaculate. Significant positive correlations were found within rams between volume and concentration for both ejaculates during the June period. There was no consistent association between first and second ejaculate to volume. Correlations between volume and motility grade were low and not significant with the exception of that found in the

second ejaculate for the daily collection period, which was positive. Correlations between motility grade and concentration were positive, but low.

THE FRUCTOLYSIS OF BOVINE SEMEN AND ITS RELATION TO FERTILIZING ABILITY. R. S. Sechrist and A. B. Schultze, *University of Nebraska.*

The rate of fructolysis of bovine semen has been reported to be related to the fertilizing capacity. To obtain further data on this relationship, a study was made of the initial fructose content and the rate of use of fructose of 28 semen samples. These two characteristics were studied in relation to the non-return rate obtained from the use of this semen in artificial breeding. The mean fructose content was 472 mg. per 100 ml. semen. The mean fructolysis rate per 10^9 spermatozoa per hour at 37° C. was 1.2 mg. The correlation coefficient expressing the relationship between initial fructose content and non-return rate was +.317; the one expressing the relationship between rate of fructolysis and non-return rate was +.290. Neither of these coefficients was statistically significant.

THE EFFECTS OF TESTOSTERONE AND ESTRADIOL BENZOATE UPON GROWTH, EFFICIENCY OF FEED UTILIZATION AND CARCASS CHARACTERISTICS OF SWINE. R. B. Sleeth, A. M. Pearson, H. D. Wallace, and D. H. Kropf, *University of Florida.*

In the first trial fourteen purebred Duroc and Hampshire pigs averaging approximately 36 pounds were divided into two lots of seven pigs in each. Lot 1 served as controls and Lot 2 was injected intramuscularly with 1 mg./kg. of body weight of testosterone propionate weekly for the first six weeks; thereafter, the injections were given biweekly. All pigs were fed the same ration and slaughtered after 115 days. Average daily gains were 1.40 and 1.25 pounds for Lots 1 and 2, respectively. Differences in feed consumption, average thickness of backfat, tenderness and carcass grades were not statistically significant. Organaleptic ratings indicated that testosterone injections at the levels used did not measurably influence the palatability of roasts from treated animals. In the second trial pigs averaging 46 pounds were divided into four lots of five barrows and five gilts per lot and treated as follows: (1) control, (2) testosterone propionate—0.5 mg./kg. body weight administered biweekly, (3) estradiol benzoate—1.0 mg./kg. body weight administered biweekly, and (4) combination of estradiol benzoate and testosterone propionate administered biweekly (0.5 mg./kg. testosterone and 1.0 mg./kg. estradiol). After 39 days, average daily gains were 1.11, 1.10, 1.05 and 1.03 pounds for Lots 1, 2, 3 and 4, respectively. A swelling of the vulva of the gilts and marked enlargement of the mammary glands of both barrows and gilts were observed in Lot 3; whereas, the pigs receiving both testosterone and estradiol (Lot 4) appeared normal.

A STUDY OF THE MATURATION PROCESS OF THE OVUM OF THE SOW DURING NORMAL AND INDUCED OVULATIONS. J. F. Spalding and R. O. Berry, *Agricultural and Mechanical College of Texas.*

This study was made in an effort to determine whether or not the nucleus of the ovum of the sow during induced ovulations had matured in a normal manner, or if they were ovulated in an immature state. The ova of some 200 gilts and sows in the follicular and luteal phase of the estrous cycle were studied to establish the normal maturation process of the ovum. The maturation process was found to begin shortly after the onset of heat. Meiosis is preceded slightly by a radial dispersion of the discus proligerus which surrounds the

follicular ovum. The first metaphase plate occurs about 26 hours after the onset of heat, and the first polar body and second maturation plate are present at 36 hours after the onset of heat. At the time of ovulation the ovum is in the second metaphase plate and remains in this condition until fertilization. If fertilization does not take place, the metaphase chromosomes migrate randomly toward the spindle poles and the ovum undergoes parthenogenic segmentation, fragmentation or some other degenerative process. The egg plug, found in the fimbriated end of oviduct is formed by several proligerus discuses which are still surrounding the ovum when it is released from the follicle. Ovulation was induced in 7 luteal gilts and 5 follicular gilts by injections of from 35 to 45 Armour units of gonadotropin. All but 1 of the ova recovered from the oviducts of these gilts were in the second maturation spindle, and appeared to be normal. Many of the follicles which did not ovulate contained eggs whose nucleus was undergoing meiotic divisions even though the follicles were small (4 mm).

THE EFFECT OF OXYTOCIN ON MILK AND FAT PRODUCTION AT ALTERNATE 14-DAY PERIODS DURING LACTATION. D. G. Sprain, O. T. Fosgate, Vearl R. Smith, and W. J. Tyler, *University of Wisconsin and U. S. Department of Agriculture.*

Seven cows are being injected intravenously with 10 I.U. of oxytocin prior to milking at alternate 14-day intervals during lactation. The first day of each control and experimental period is considered transitional. Fat tests are made on samples of milk from the day of transition, day—2, composites of days —7, —8, and —9, and day—14. Three cows that have been on the experiment 5 months have produced approximately 2 lbs. more milk per day during injection periods than during the control periods. The fat content of the milk during the injection periods averaged 0.25 percent higher than that of the milk produced during the control intervals.

THE GONADOTROPHIC HORMONE CONTENT OF COW PITUITARIES AS INFLUENCED BY PREGNANCY AND STILBESTROL TREATMENT. E. W. Swanson and A. Quddoos, *University of Tennessee.*

A group of dairy cows brought for slaughter during Dec., 1951 and Jan., 1952 were examined for pregnancy. Non-pregnant heifers and cows which were dry or nearly so and non-pregnant, were considered to have been culled because of breeding trouble. In order to test a commonly used treatment for such cows, 2 groups of 10 and 11 were injected respectively with 20 mg. and 60 mg. of stilbestrol in oil intramuscularly 24 hrs. before slaughter. Pituitary glands and ovaries were collected from these as well as 14 open dry cows, 22 open lactating cows, 13 early pregnant cows, 17 late pregnant cows, 7 open heifers and 2 pregnant heifers. Assays of gonadotrophic and thyrotrophic hormone were made of the individual pituitaries and comparisons made with the reproductive condition. Average gonadotrophic potency of the groups ranked in order from lowest to highest: 20 mg. treated open cows, 60 mg. treated open cows, open dry cows, open lactating cows, open heifers, early pregnant cows, pregnant heifers, and late pregnant cows. The highest group was about 40% above the lowest. A significant positive correlation ($r=.28$) was found between gonadotrophic potency and corpus luteum weight. The differences between the groups in thyrotrophic potency were not significant. Apparently many of the non-pregnant cows were low in gonadotrophic hormone, and this condition was not remedied by stilbestrol treatment.

THE AMOUNT OF RESIDUAL MILK AND THE HEIGHT OF INTRAMAMMARY PRESSURE INDUCED BY INJECTIONS OF PITUITRIN, PITOCIN, AND PITRESSIN. Joseph Szasz and Ralph P. Reece, *New Jersey Agricultural Experiment Station.*

Ten to 60 international units of pituitrin, pitocin, or pitressin were injected intrajugularly into 4 Jersey cows in various stages of lactation and gestation following p.m. machine milking. The results show that an average dose of 32 units of pituitrin induced an average intramammary pressure of 24 mm. Hg and 2.2 lbs. (20.4%) of residual milk. With an average dose of 32 units of pitocin the average intramammary pressure was 13.4 mm. Hg and 1.5 lbs. (17.2%) of residual milk. An average dose of 32 units of pitressin resulted in an intramammary pressure of 11.2 mm. Hg and 0.9 lb. (10.6%) of residual milk. Therefore, pituitrin was 1.8 times as effective as pitocin and 2.2 times as effective as pitressin in increasing intramammary pressure. As measured by the amount of residual milk made available, pituitrin was 1.5 times as effective as pitocin and 2.4 times as effective as pitressin. Pitocin was only slightly more effective (1.2 times) than pitressin in increasing intramammary pressure, but 1.7 times as effective in making the residual milk available to the milker. Pitressin appeared to be more effective in increasing intramammary pressure than it was in making the residual milk available to the milker. The average butterfat content of all the residual milk samples was 13.6%.

THE VALIDITY OF THE LIVE-DEAD DIFFERENTIAL STAINING TECHNIQUE. E. P. Warren, D. T. Mayer, and Ralph Bogart, *University of Missouri.*

Ten composite samples of ram semen were divided into two portions; one of which was subjected to one of five different treatments designed to kill most or all of the spermatozoa present. These treated portions were then added quantitatively to their respective untreated portions in five different proportions. The differential staining technique was applied on the treated portions and on all five different dilution levels in order to determine whether this technique consistently and quantitatively differentiates between live spermatozoa (consisting largely of those in the original samples) and dead spermatozoa (derived primarily from treated portions of the samples) regardless of the treatment causing spermatozoan death. Comparisons were made between actual and calculated percentages of live, unstained, cells at each level of dilution. Three different stains or staining mixtures were compared for degree of accuracy, two with each composite sample. The influence of pH on the staining reaction was studied using four composite semen samples. Each of the four samples was divided into three equal portions, each of which was diluted with isosmotic phosphate buffer of a different pH level. The pH values of the buffer solutions were 6.6, 7.0 and 7.4. Eosin, erythrosin and an opal blue-eosin mixture gave comparable results under varying conditions of pH, proportion of live and dead spermatozoa and cause of spermatozoan death. The validity of the live-dead differential staining technique is indicated by the fact that known quantities of dead spermatozoa when added to normal semen in any known quantity were accurately differentiated from the live cells.

RELATIONSHIP BETWEEN FAT GLOBULE SURFACE AREA AND CAROTENE AND VITAMIN A CONTENT OF MILK IN SUCCESSIVE PORTIONS OF A MILKING. R. F. White, Geoffrey Beall, and H. D. Eaton, *University of Connecticut.*

Skim and whole milk samples of successive portions of four single quarter milkings from each of four Holstein cows in their first lactation were studied.

Skim milk was significantly higher in carotene and vitamin A per gram of fat and in globule surface to volume ratio than was the whole milk from which it was separated. Within the range of whole milk values studied, carotene and vitamin A per gram of fat had positive linear correlation with globule surface to volume ratio ($P<0.05$). Fat, carotene, and vitamin A percentages in the milk all showed highly significant increases with successive milking portions. Carotene per gram of fat declined to a minimum near the milking mid-point and thereafter increased ($P<0.001$). Vitamin A per gram of fat showed a slight tendency to decline throughout the milking ($P<0.10$). While carotene and vitamin A per gram of fat both appeared to be correlated with stage of milking, no such correlation was found after globule surface to volume ratio was accounted for. Calculations indicated that the surfaces of fat globules had over 100 times the concentration of carotene and vitamin A as had their interior portions.

DEVELOPMENT OF THE PENIS IN RAM LAMBS. Earl L. Wiggins and Clair E. Terrill, *U. S. Sheep Experiment Station, and Western Sheep Breeding Laboratory.*

At birth the glans penis and processus urethra of the ram lamb are adhered to the preputial mucosa, the urethral process lying in a groove on the wall of the prepuce. The adhesions gradually break down as the lamb gets older so that the prepuce can be everted and the penis exposed. The developmental process can be divided in five fairly well defined stages which were scored as follows: (1) infantile condition, (2) urethral process free, (3) tip of glans free, (4) free to below glans and (5) adult condition. The stage of development was scored at weaning time, at ages of 91 to 155 days in 1,250 ram lambs born in 1951. Although developmental scores of 3 and 5 were found in lambs 91 and 103 days old respectively, the organs of a number of the oldest lambs examined were still in an infantile condition. There were significant breed differences in development; 278 Columbias and 359 Targhees, both weaned at an average age of 115 days, had mean scores of 2.45 and 2.37 respectively while 613 Rambouillets, weaned at an average age of 125 days, had a mean score of only 1.87. Corresponding standard deviations for the three breeds were 1.32, 1.20 and 1.09. The coefficients of variation were higher in inbreds than in outbreds of the same breed in Columbias and Rambouillets but not in Targhees. Simple correlation coefficients of penis scores with other weanling traits were: age, 0.092**; inbreeding, —0.086*; weight, 0.440**; condition, 0.270**; staple length, 0.175** and index, 0.308**.

FERTILITY OF SEMEN COOLED AT DIFFERENT RATES. E. L. Willett and G. L. Larson, *American Foundation for the Study of Genetics.*

Two split-collection experiments with latin-square designs have been conducted to compare four methods of handling and cooling bull semen immediately after collection: (a) diluting 1:4 immediately after collection and cooling to 5° C. in about 40 minutes; (b) same as (a) except cooled in about 60 minutes; (c) same as (a) except cooled in about 2⅓ hours; and (d) diluted 1:4, held on laboratory desk for one-half hour, and cooled at same rate as (b). The diluter was yolk-citrate with sulfanilamide, penicillin and streptomycin. Final dilutions to reduce spermatozoan numbers to 4 to 22 million per ml. were made after the semen was completely cooled. Totals of 5,726 services, 20 collections and 8 bulls were involved. The over-all average 28–35 day non-returns to first services made the day after collection for the different treatments were: (a) 79.4, (b) 80.9, (c) 81.0, and (d) 81.5. There is a trend indicating that slow cooling

is preferable, although there were no significant differences between the means. The holding of diluted semen at room temperature one-half hour before cooling is not harmful.

REFRACTORINESS OF DAIRY COWS TO REPEATED ADMINISTRATION OF GONADOTROPHINS. E. L. Willett, W. H. McShan, and Roland K. Meyer, *American Foundation for the Study of Genetics and University of Wisconsin.*

Parous cows were treated at intervals with gonadotrophins to produce superovulation and to study the effect that such repeated administration may have upon response. In general the treatments consisted of either (a) five daily subcutaneous injections of sheep pituitary or hog pituitary FSH followed on the sixth day by an intravenous injection of unfractionated sheep pituitary gonadotrophin or (b) one subcutaneous injection of equine gonadotrophin followed five days later by an intravenous injection of human chorionic gonadotrophin or unfractionated sheep gonadotrophin. Each of these treatments was started on the fifteenth or sixteenth day of the cycle. In most cases the same doses of the same preparations were given with successive treatments for a given animal. The response to gonadotrophins was measured by counting corpora lutea. This was done by making an incision through the dorsal wall of the vagina and the peritoneum of the recto-vaginal pouch, drawing the ovaries into the vagina and examining them. Nineteen cows have received a gonadotrophin treatment two to six times. In general there has been a progressively smaller number of corpora lutea following each successive treatment. Initial responses varied from two to forty corpora lutea. In most cases, only one or no corpus luteum was observed after the third or fourth treatment. Two cows which had two corpora after the first treatment had none after the fourth.

A STUDY OF ATRETIC LARGE FOLLICLES IN SIX LINES OF HOLSTEINS. J. N. Wiltbank, W. J. Tyler, and L. E. Casida, *University of Wisconsin and U. S. Department of Agriculture.*

Atretic large follicles (follicles 25 mm. or more in diameter not associated with an ovulatory estrus) were found in 11.3% of 274 reproductive periods and in 20.0% of 135 cows in the experimental breeding herd at the Emmons Blaine, Jr. Experimental Farm, Lake Mills, Wisconsin. The incidence of atretic large follicles was not affected significantly by year, milk producing ability, length of interval to involution of the uterus, or by loss of pregnancy. Significant differences in the incidence of atretic large follicles were found between months of the year and between the first and later reproductive periods of the cows. Highly significant differences were found in the incidence of atretic large follicles between lines and also in the proportion of cows that had an atretic large follicle for the first time at different intervals postpartum. In some lines and in some reproductive periods breeding efficiency was lowered significantly when atretic large follicles were present. In other lines and reproductive periods there apparently was no association between breeding efficiency and presence or absence of atretic large follicles. This difference in response may be due to particular physiological variations of atretic large follicles found in these lines or reproductive periods.

IDENTICAL TWINS IN STUDIES OF INTERRUPTED GROWTH OF BEEF CATTLE. C. F. Winchester, *U. S. Department of Agriculture.*

Interrupted growth studies with 6 pairs of identical twin beef animals have been completed at Beltsville. One member of each pair was used as a

well-fed control, while the other received a ration that was adequate except with respect to energy. Animals kept on rations that approximated maintenance with respect to energy value between the ages of 3 and 6, 4 and 8, and 6 and 12 months either gained very little or lost weight. Other calves kept on rations approximatly equal to 80 percent of maintenance from the ages of 3 to 6 or 4 to 8 months lost weight during the first 3 to 8 weeks on the low ration and then remained at nearly constant weight even though the allowances had been reduced in accordance with the lower body weights. All animals that had been on limited rations apparently were in good health when the period of reduced energy allowances ended, and they gained weight as rapidly as their controls when their allowances were returned to an adequate level.

LACTATIONAL EFFECTS OF PITUITARY HORMONES IN VIRGIN DAIRY HEIFERS. T. R. Wrenn and J. F. Sykes, *U. S. Department of Agriculture.*

A comparison of the lactation stimulating effects of prolactin and a growth hormone preparation has been made in 11-month old dairy heifers in which udder development was induced by stilbestrol or stilbestrol plus progesterone. The growth hormone preparation, which contains thyrotropic hormone in addition to the growth hormone, has produced more copious milk secretion in these heifers than prolactin. Milk production is variable between heifers and has varied from 7.0 to 15.0 lbs. daily.

Teaching Section

A. L. Anderson, *Chairman*

THE USE OF LEGUME-HAY-ENERGY EQUIVALENTS IN CALCULATING RATIONS FOR STOCKER CATTLE. Roscoe R. Snapp, *University of Illinois.*

A method of estimating the feed requirements and average daily gains of dry beef cows and stocker calves based upon the published net energy values of feeds has been used in classroom teaching for several years at the University of Illinois. For simplification and ease of application the weight of each feed that will supply the same amount of net energy as 5 pounds of legume hay has been calculated and is called the "legume-hay-energy equivalent" (LHEE) of that feed. These factors are whole numbers and can be easily memorized and used without reference to published tables. Energy requirements of stocker cattle are assumed to vary directly with the live weight and with the rate of gain. Consequently for a given ration, the rate of gain can be easily calculated. Conversely, a ration can be quickly computed which will produce the approximate daily gain desired. The calculated results agree sufficiently closely with the published results of actual feeding experiments as to justify the use of the method in both classroom and feed lot. In the classroom it is a valuable means of giving training in clear thinking and in the solution of practical problems.

AN ANNOUNCEMENT OF AND RULES CONCERNING THE MORRISON AWARD *

Professor F. B. Morrison of Cornell University, Ithaca, New York, and his wife, Elsie R. Morrison, have established a trust for the establishment and maintenance of an award each year to a member of the Society who has done outstanding recent research that has been of direct importance in livestock production. The award is to consist of a cash award not to exceed one thousand dollars ($1,000) and a gold medal or other suitable permanent form of recognition. The donors wish in this manner to express their appreciation of the help they have received from animal and dairy husbandry men in compiling the book, *Feeds and Feeding*. The awards are to be administered by the American Society of Animal Production under rules of its formulation. The Executive Committee of the Society unanimously accepted the funds and agreed to make the awards in accordance with the general and liberal wishes of the donors who will in no way influence decisions with respect to recipients.

The Executive Committee has formulated and adopted the following regulations and all awards shall be made in accordance with these stipulations.

1. To be eligible for the Morrison Award a nominee, who must be a member of the American Society of Animal Production, shall have made a meritorious scientific contribution or discovery in research in the field of animal husbandry.

2. The award is limited to living citizens of the United States and Canada actively engaged in research.

3. No officer or member of the Executive Committee of the American Society of Animal Production or member of committees concerned with the award shall be eligible for the award while holding such positions.

4. The research must pertain to the following classes of animals: (a) beef cattle, (b) dairy cattle, (c) horses, (d) sheep, or (e) swine.

5. The research must relate to some phase of breeding, feeding, management, nutrition or physiology, or to the meats of the animals listed above in Item 4, and must have direct importance in their production.

6. The work on which the award is based may have extended over

* The original statement of the Morrison Award was made in the JOURNAL OF ANIMAL SCIENCE 5:236–237, 1946, and was amended by the Executive Committee as shown in JOURNAL OF ANIMAL SCIENCE 7:257, 1948.

a considerable period of years but must have been completed or be in progress within the ten-year period preceding the year in which the award is made. Some report of the research work must have been published within a five-year period of the time at which the award is made.

7. Total recent accomplishment in a certain field as well as research relating to any particular problem may be the basis of the nomination for the award and such work shall be considered in determining recipients.

8. There are no restrictions with respect to race, sex or age.

9. There is no limit to the number of times a member can be nominated but an individual cannot receive the award more than once.

10. The award may be to co-workers if deemed advisable by the Award Committee.

11. Any member of the Society except the officers and Executive Committee and members of the Awards Committee may make one nomination in any one year. Such nomination shall be made to the Secretary in writing and must be received before June 15 of the year in which such nomination was made. The Award Committee may invite and consider additional nominations.

12. A nomination made in one year may be considered in subsequent years by the Awards Committee.

13. The Award Committee shall consist of five members. The Vice President shall be Chairman of the Committee. The President of the Society shall appoint the other members with the advice and approval of the majority of the Executive Committee. Two members shall be appointed each year and appointees will serve a two-year term. Any vacancies that occur in the Committee shall be filled by appointees named by the President.

14. All nominations must be accompanied by:

a. A brief biography of the nominee.
b. A list of publications concerning the research of the nominee.
c. Copies of the publications concerning the research of the nominee.
d. A statement of the importance to the livestock industry of the work upon which the nomination is based.

15. After nomination has been made, solicitation on behalf of any nominee by individuals, groups, or institutions, will not be tolerated and such solicitation will automatically make the nominee ineligible for the award.

16. All nominations, together with supporting material, received by the Secretary will be transmitted to the Chairman of the Award Committee immediately after closing date for nominations and the Committee shall report its selection to the Secretary not later than October 15. The material supporting nominations may be held by the Award Committee for such period of time as desired and then shall be returned to the person or persons who made the submission.

17. The decision of the Award Committee in the selection of a recipient shall be final. If the Committee decides none of the nominees is deserving the award, no award will be made that year.

18. The presentation of the award will be made under appropriate circumstances at the time of the annual meeting of the American Society of Animal Production.

19. The Executive Committee may make necessary changes in these regulations for awards in subsequent years.

NEWS AND NOTES

The forty-fourth annual meeting of the American Society of Animal Production will be held in the Hotel Sherman in Chicago, Illinois, on November 28 and 29, 1952, with a dinner for the honored guest on November 30. Abstracts of most papers which are to be presented at the meeting are published in this issue of the JOURNAL OF ANIMAL SCIENCE.

The nominating committee of the American Society of Animal Production composed of A. D. Weber, P. S. Shearer and W. G. Kammlade has prepared the following list of candidates to be presented at the next election of officers in the annual business meeting in Chicago on November 29.

For President:

M. L. Baker

For Vice-President:

A. E. Darlow

W. L. Henning

George Hyatt, Jr., formerly a member of the dairy husbandry staff of the University of West Virginia and more recently Farm Manager and Editorial Consultant with *Hoard's Dairyman,* Fort Atkinson, Wisconsin, joined the dairy extension staff of the Department of Animal Industry of North Carolina State College on August 1, 1952. He will spend his full time in the dairy extension program.

General Genetics, by Srb and Owen, was published by W. H. Freeman and Co., San Francisco, in June 1952. The science of genetics is presented together with its general biological implications. An attempt is made to present the subject in terms of the effect of hereditary units in dynamic interplay with environment on the development and function of organisms. The organization of the book is intended to make it adaptable to courses of different scope.

Fred F. McKenzie, professor of animal husbandry and department chairman, Oregon State College, is on sabbatic leave in Australia (April 1, 1952 to March 31, 1953) (Fulbright). His assignment is to design the first "faculty of animal husbandry" for Australia which is to be established at New England University College, Armidale, New South Wales. McKenzie is visiting producers and institutions in an effort to learn their problems before making recommendations.

Joe B. Johnson is acting chairman, department of animal husbandry, Oregon State College for the year ending March 31, 1953 while Fred F. McKenzie is on leave in Australia.

Fundamentals of the Histology of Domestic Animals, by Trautmann and Giebiger has been translated from the German and revised by Habel and Biberstein. Comstock Publishing Associates, Ithaca, N. Y. published the book in June, 1952. The histology of the horse, ox, goat, pig, dog, cat and fowl is covered. Important species differences are stressed. Particular emphasis is placed on the relation of histology to the physiology and pathology of domestic animals.

Albert J. Reed, Extension Animal Husbandman at the University of Nevada, retired July 15th, 1952, after 31 years service. He was succeeded by Lyle O. McCartney who received the B.S. degree in Animal Husbandry at the University of Nevada in 1949. McCartney was Assistant County Agent for livestock in Elko County.

M. T. Clegg has completed graduate work in animal physiology at the University of California and joined the Animal Husbandry staff at the University of Nevada. He will conduct research and teaching in animal physiology.

James E. Hunter, who received the B.S. degree in animal husbandry from

the University of California in 1939, has joined the animal husbandry staff at the University of Nevada. He will serve as manager of the university's South Virginia farm and beef cattle herdsman.

Advanced Statistical Methods in Biometrical Research, by C. R. Rao, was published by John Wiley and Sons, Inc., New York in June, 1952. The author has attempted to provide a theoretical groundwork for the different statistical methods and to illustrate computational procedures by working out a number of problems.

Donald J. Balch joined the Department of Animal and Dairy Husbandry, University of Vermont, July 1, 1952. He will serve as assistant animal husbandman in the Experiment Station, cooperating in the horse and sheep breeding work at the Morgan Horse Farm, Middlebury. He is a graduate with Master's degree from the University of New Hampshire.

Symposium on Radiobiology, edited by J. J. Nickson, was published by John Wiley and Sons, Inc., New York in May, 1952. It is a report of papers and discussions presented at the Oberlin Symposium on Radiobiology in June 1950. In addition to the physical and chemical changes involved in radiations, examination is made of biochemical effects and changes occurring in living tissues.

Verle R. Bohman has completed graduate work in animal nutrition at Cornell University and joined the animal husbandry staff at the University of Nevada. He will conduct research and teaching in animal nutrition.

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